

Installation and Operation of Particle Transport Simulation Programs to Model the Detection and Measurement of Space Radiation by Space-Borne Sensors

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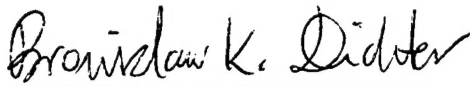
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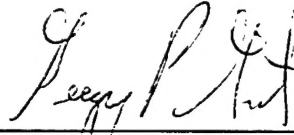
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13. ABSTRACT (Maximum 200 words) This document is a report of the technical progress made during the period 10 Aug. 1999 - 31 July 2000 in the areas of: (1) research and evaluation of particle transport simulation programs for modeling the detection and measurement of space radiation by space-borne sensors; (2) construction of realistic flight sensor computer models; (3) performance of particle transport calculations; (4) analysis of transport simulation results, including single particle tracking; (5) transfer and facilitation in the implementation of particle transport simulation technology to AFRL. Several computer programs (LAHET, ACCEPT, CYLTRAN, MCNPX) for particle transport simulation were applied to the modeling of the CEASE and HEP sensors. In addition, a preliminary version of a post-processor program for analysis of single particle histories from MCNPX was written. Shown in this report are several listings of input files, with geometry/materials drawings, for the various simulation programs, an example of (excerpt from) a track file analysis, and partial listings of code outputs.			
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1. Introduction

The effort to be described in this report was performed as partial fulfillment of two primary objectives: (1) perform computer simulations of charged particle transport, energy and charge deposition in satellite-borne instrumentation used in research efforts of the Air Force Research Laboratory/ Space Weather Center of Excellence (AFRL/VSBXR) to detect and characterize (by type, energy, intensity, *etc.*) particles associated with ionizing radiation in space; and (2) transfer this simulation capability to AFRL/VSBXR and provide advice to Air Force researchers on its use. These simulations provide valuable assistance to scientists and engineers in the design and evaluation of on-board radiation measurement instrumentation.

During this reporting period we worked with the Monte Carlo simulation programs listed below at ARCON, and with the exception of the first, recommended installation of these programs and provided assistance and guidance for their use at AFRL. The Monte Carlo transport simulations programs that were used in the effort are:

- "LCS – The LAHET Code System" [1] - Transport code for protons, neutrons, mesons, deuterons, tritons, ^3He , alpha, photons
- "ITS 3.0 – Integrated TIGER Series of Coupled Electron/Photon Monte Carlo Code System" [2]
 - a) TIGER – One-dimensional (slab geometry) multilayer code
 - b) CYLTRAN – Cylindrical (axisymmetric) geometry code
 - c) ACCEPT – General three-dimensional transport code
- "MCNPX, Version 2.1.5 – Monte Carlo transport code for neutrons, photons, electrons, mesons, protons, deuterons, tritons, ^3He , alpha" [3]

All but two of these codes utilize three-dimensional models of the transport medium, *i.e.* particle telescope or particle detection instrument. The exceptions are CYLTRAN, which applies only to 3-D models of cylindrically symmetric objects and TIGER, which is applicable only to simple multiplayer 1-D slab geometry.

MCNPX, Version 2.1.5, the most recent version of the Los Alamos Monte Carlo program MCNP[4] came into existence in November, 1999. The capabilities of this program far exceed those of LAHET and ITS. It has proven to be an excellent tool for transporting protons, electrons, neutrons and photons in the Compact Environmental Anomaly Sensor (CEASE)[5] and High Energy Proton (HEP)[6] sensor.

The visual editor program, MCNP-VisED[7], an adjunct to the MCNP codes, provides the capability to create and visualize MCNP geometry description files. MCNP-VisED was acquired and used primarily to display the geometry files that were created for CEASE and HEP. It has proven to be a valuable addition to the library of programs selected for this project, particularly as a tool for detecting errors in geometry model files.

In the following sections, we briefly discuss the computer programs listed above, some of their interrelationships, and provide descriptions and examples of our application of these codes to the modeling of particle transport and trajectory tracking in the CEASE and HEP instruments.

2. Monte Carlo Simulation Programs

2.1 LCS – The LAHET Code System [1]

At the outset of this effort, the LAHET Code System was used to model proton transport in the CEASE instrument. LAHET is a Monte Carlo code for the transport of nucleons, pions, and muons, and is based on the CALOR95/HETC [8] code that was originally developed at Oak Ridge National Laboratory. LAHET has a significant advantage over its predecessor, HETC, in that it uses the same problem geometry description method as that used in an early version of the LANL neutron-photon Monte Carlo code MCNP [4]. We have found that the MCNP outperforms any other simulation code with respect to geometry description. LAHET allows the user to choose between two intranuclear cascade models to describe the physics of nuclear interactions, the Bertini model (used in HETC) and the ISABEL [1] model which allows hydrogen, helium ions and antiprotons as projectiles and uses the Fermi breakup model for the breakup of light nuclei instead of the evaporation model incorporated in the Bertini model. The LCS-LAHET code system also provides a post-transport code (HTAPE [1]) for the analysis of the particle history file written by LAHET. This program has a large number of analysis options that allow the user to perform audits for energy deposition, mass and energy balance, particle conservation, surface fluxes and currents, and internal neutron fluxes. LAHET simulations of proton transport and trajectory tracking were performed during the past year for both the CEASE and HEP instruments.

2.2 The ITS 3.0 Code System [2]

The major portion of our modeling work for electron transport in the CEASE and HEP sensors was performed with the Integrated TIGER series of Coupled Electron/Photon Monte Carlo codes, a set of programs that efficiently solves electron/photon transport problems. These programs contain detailed physical models for electron and photon scattering and transport, secondary electron production, bremsstrahlung production, straggling and knock-on electron production. Some of these physical options can be “switched on or off” to isolate these effects and estimate their significance. For the purposes of modeling electron transport in CEASE and HEP, we found that two of the three ITS codes to be of use, CYLTRAN[2b] and ACCEPT[2c]. CYLTRAN, in some cases, could be used for HEP, while ACCEPT, the more general three-dimensional code, was applied to HEP and CEASE. Taking advantage of cylindrical symmetry, such as may be the case for instrument engineering models, CYLTRAN runs much more quickly than ACCEPT for the same problem. However, for full adherence to realistic situations, *i.e.* full production (flight) versions of these sensors, the use of ACCEPT is preferable.

2.3 MCNPX, Ver. 2.1.5 [3]

In March 1999, we acquired and installed the MCNP4B2[4] and MCNPX codes at ARCON. MCNPX incorporates all of the advantages of the Los Alamos MCNP code system, such as problem geometry specification and code documentation, while permitting transport of 34 particle types (including antiparticles). In order to make effective use of MCNPX, considerable experimentation with various input data types and geometry models was required. We found it necessary to rewrite the geometry, materials and source specifications for the CEASE and HEP input files, since several incompatibilities were found to exist between the formats required for this later version of MCNP (MCNP4B2 and MCNPX) and the earlier MCNP, Ver. 3 used in LAHET. After the initial “break-in” period, we concluded that MCNPX is the best overall program to be used for analysis of particle transport in space-borne sensors such as CEASE and

HEP. The obvious advantage to having one code that “does it all” is that only one geometry/material specification file is required for all particle transport problems. Furthermore, MCNP provides what is, in our opinion, the best geometry modeling capability of any of the available transport codes. We did find one disadvantage, however. The electron transport run times are much longer than their ITS counterparts, so that if computational effort and/or turn-around time become significant issues, use of ITS is preferable.

The three computer program collections, LCS-LAHET, ITS and MCNPX were not developed completely independently from one another and, in fact, share common “ancestry”. The choice of MCNPX for most of our particle transport work is based on our opinion that MCNPX combines the best features of its predecessor codes: 1) the coupled electron/photon physics of ITS; 2) the proton transport and nuclear interaction physics of LAHET; and 3) the photon and neutron transport physics, cross-section libraries and geometry description capability of MCNP.

2.3.1. MCNP-UISED – Visual Editor for MCNP Input Files [7]

In addition to the Monte Carlo programs, we acquired and installed the MCNP geometry model visualization and construction program, MCNP-UISED[7]. We found that this program was extremely useful for visualizing and checking the validity of existing geometry models. The program displays the model in any number of modes and orientations. With it we have the ability to display all or part of the model, with or without surface labels, and with or without cell labels. In the color picture mode, a unique color designation is assigned to each material used in the problem. This program also checks and finds most geometry modeling errors. Simple typographical errors in the geometry specification file are usually difficult to identify in the file, however they show up prominently on the screen.

3. Proton Transport Modeling – CEASE Telescope [5]

3.1 LAHET CEASE Simulations

The Compact Environmental Anomaly Sensor (CEASE) instrument (see Figure1) overall dimensions are 10 x 10 x 8.2 cm. Looking top-down, the package is divided into four quadrants containing: 1) the energetic particle telescope to measure proton energy spectra; 2)&3) dosimeters; 4)p-i-n diode for single event effects measurement. The entire instrument is enclosed by an Al cover with a hole in one top corner to allow for the telescope aperture. The telescope geometry is cylindrical, has a tungsten collimator with a 45° half-angle conical aperture covered by a 9 μm thick light blocking Al foil, and is surrounded by a copper cylindrical shield on the sides and back. Inside the telescope, coaxial with the telescope axis, are two cylindrical solid state detectors, one with 25 mm^2 area x 150 μm thickness and the other with 50 mm^2 area x 700 μm thickness.

Engineering drawings of CEASE were obtained from R. Redus, Amptek Corp. on 08/25/99 [5]. Using these drawings, we wrote a geometry/materials description file for the “bare” (without case) CEASE telescope for use with the LAHET Code[1]. The level of detail in the geometry/materials (10 materials, 116 surfaces, 124 cells) file is nearly the same as that supplied in the engineering drawings. After several rounds of test runs and corrections, it was determined that the geometry file was free of errors (undefined holes, overlapping cells, etc.). The surface and cell layout diagrams are shown in Figures 2 and 3, respectively.

The geometry/materials file was then expanded (10 materials, 149 surfaces, 173 cells) to include the instrument frame and case, consisting of circuit boards, corner bolts and aluminum cover. Including the frame and case allows the investigator to more closely emulate the energy-angle spectra of particles entering the telescope via paths other than through the aperture. An annotated listing of this file, which can be used as input to LAHET and MCNP (Versions 3.0 and later), is given in Appendix 1. Several LAHET runs were made for 300 MeV protons normally incident on the CEASE collimator-aperture. Energy deposition and mass-energy balance audits were run on the particle history file. This was accomplished using the LCS-HTAPE history audit program. A portion of the HTAPE output, an energy deposition audit for the 300 MeV proton source is given in Appendix 2. In addition to the HTAPE audit program, a program was written at ARCON that traces single history trajectories in the LAHET track file.

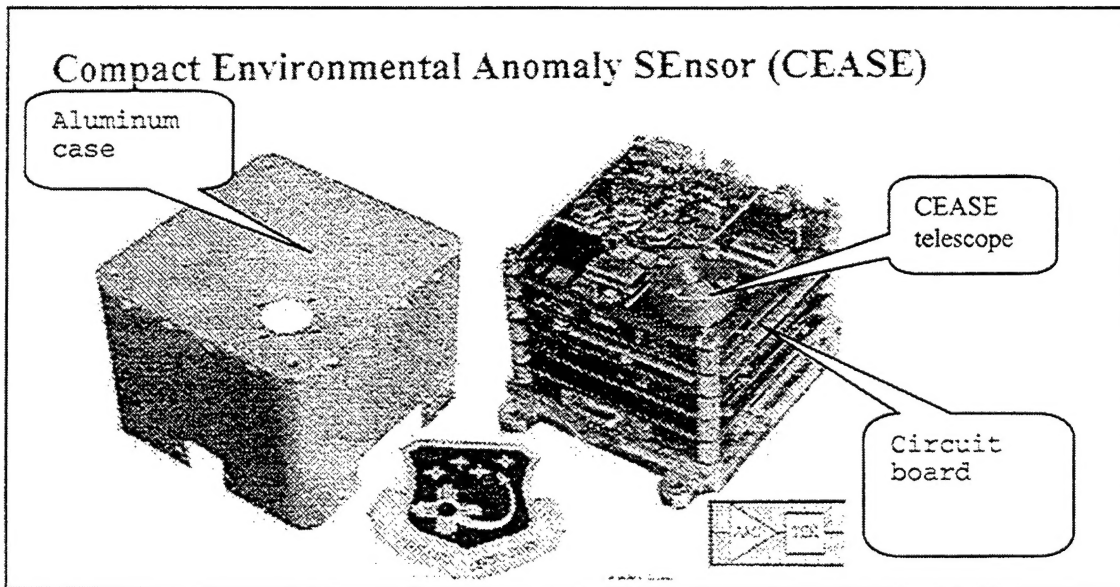


Figure 1. CEASE telescope [5,9] with case.

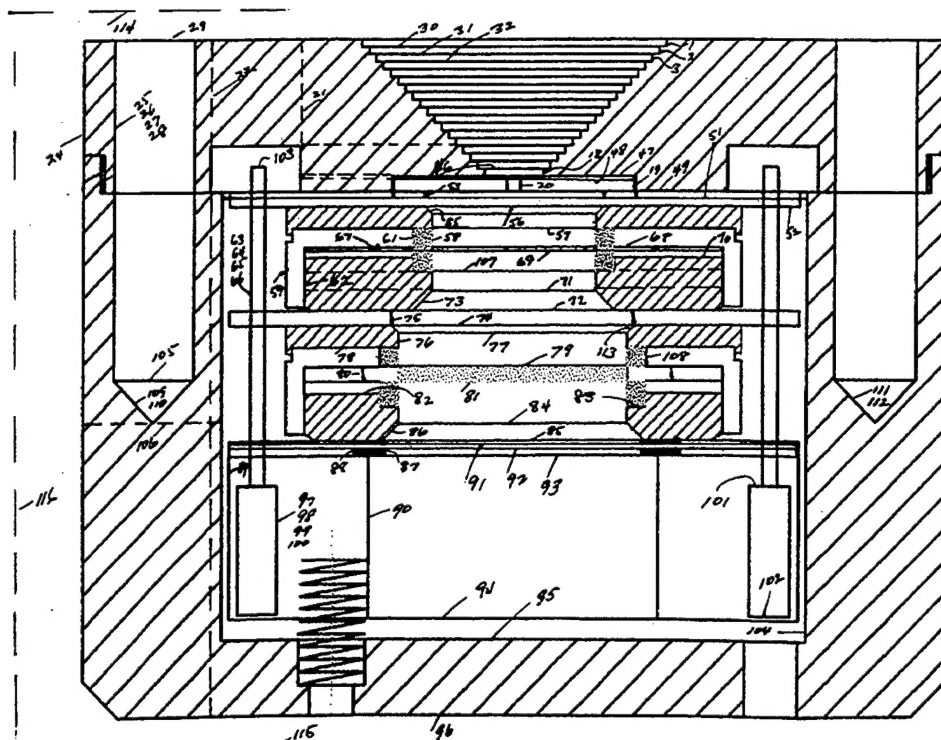


Figure 2. LAHET CEASE Telescope[9] Surface Layout (surface numbers refer to input file listed in Appendix 1).

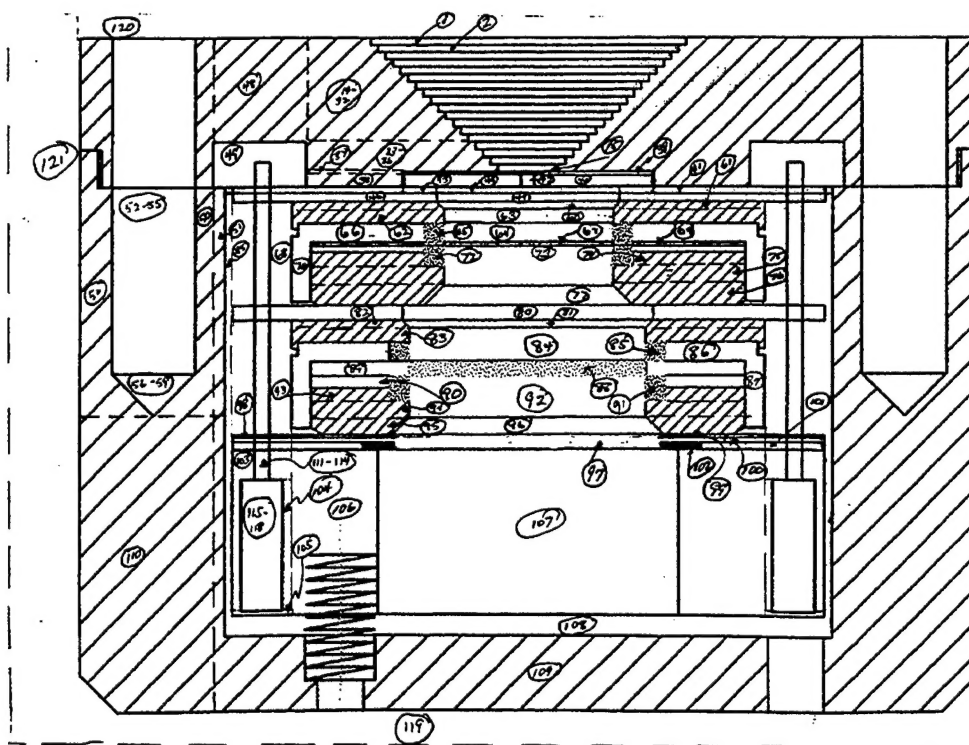


Figure 3. LAHET CEASE Telescope[9] Cell Layout (cell numbers refer to input file listed in Appendix 1).

3.2 MCNPX CEASE Simulations

With the arrival and installation of the MCNPX code in March of 1999, the effort was begun to perform the transport simulations for CEASE with MCNPX. An input file in the MCNPX format describing the geometry, including the frame and case, was written, and several test runs were made for both proton and electron sources. An input file describing a 300 MeV proton beam source entering with normal incidence through the CEASE telescope aperture is given in Appendix 3.

3.2.1 CEASE Geometry and Materials Specification

Partial diagrams of the cell and surface layouts for the CEASE telescope are shown in Figures 4, and 5, respectively. These diagrams were made using the MCNP-VisEd visualization editor. The labels shown correspond to the 173 cells and 149 surfaces listed in the input file (Appendix 3). The material designations assigned to the cells can also be viewed with VisEd utilizing color-coding. Nine materials were specified for this problem: brass, aluminum, tungsten, gold, stainless steel, conductive silicone elastomer (rubber), PMMA, silicon and copper. The exact material composition of the circuit board material is not readily attainable. However, it is known to be a mixture of fiberglass bound with epoxy resins. The high SiO₂ content and the material density closely approximating that of aluminum provide justification to assume that the circuit board material is aluminum for the purposes of our particle transport simulations. A color-coded material diagram for the telescope is shown in Figure 6.

Visualizations of the CEASE telescope geometry such as shown in Figures 4, 5 and 6, in addition to providing an effective debugging aid for problem geometry specifications, can provide a useful tool for following individual particle trajectories if augmented with coordinate axes and length units.

3.2.2 Selection of Particles for Transport Simulation (“mode” record)

Referring again to the MCNPX-CEASE input file (Appendix 3), the “mode” record (immediately following the list of surfaces) is the means by which the user selects that particles to be transported. In this calculation five particle types were selected, protons(h), neutrons(n), μ^- (|), photons(p), π^- (/). As is indicated in the source definition (SDEF) record, 300 MeV protons were assumed for the source particle (code is “par=9”).

3.2.3 Output Tally Options

For the input run file (Appendix 3) shown, the output tally options chosen are a small subset of the large number available. These included energy deposition classified by particle type: for example, photon energy deposition [heating] tallies are F46:p, F86:p; proton energy deposition tallies are +F6:h, +F106:h; charge deposition (+F58:h,...+F98:h); proton number flux (F44:h,...F84:h); proton energy flux (*F94:h,... *F134:h); and neutron number flux (F144:n,...F184:n). The integer arrays on the “F” tally records signify the cell numbers for which these tallies are to be made. An output option that is available, but was not chosen for the run shown is the calculation of pulse-height spectra for individual cells and the total for the entire geometry. Runs were made with both proton and electron sources for some of the cases that were run with the earlier codes, LAHET and ITS. As would be expected, the energy and charge deposition results obtained with MCNPX were not numerically identical with those previously obtained with the other codes, but did compare closely and for practical purposes could be regarded as equivalent.

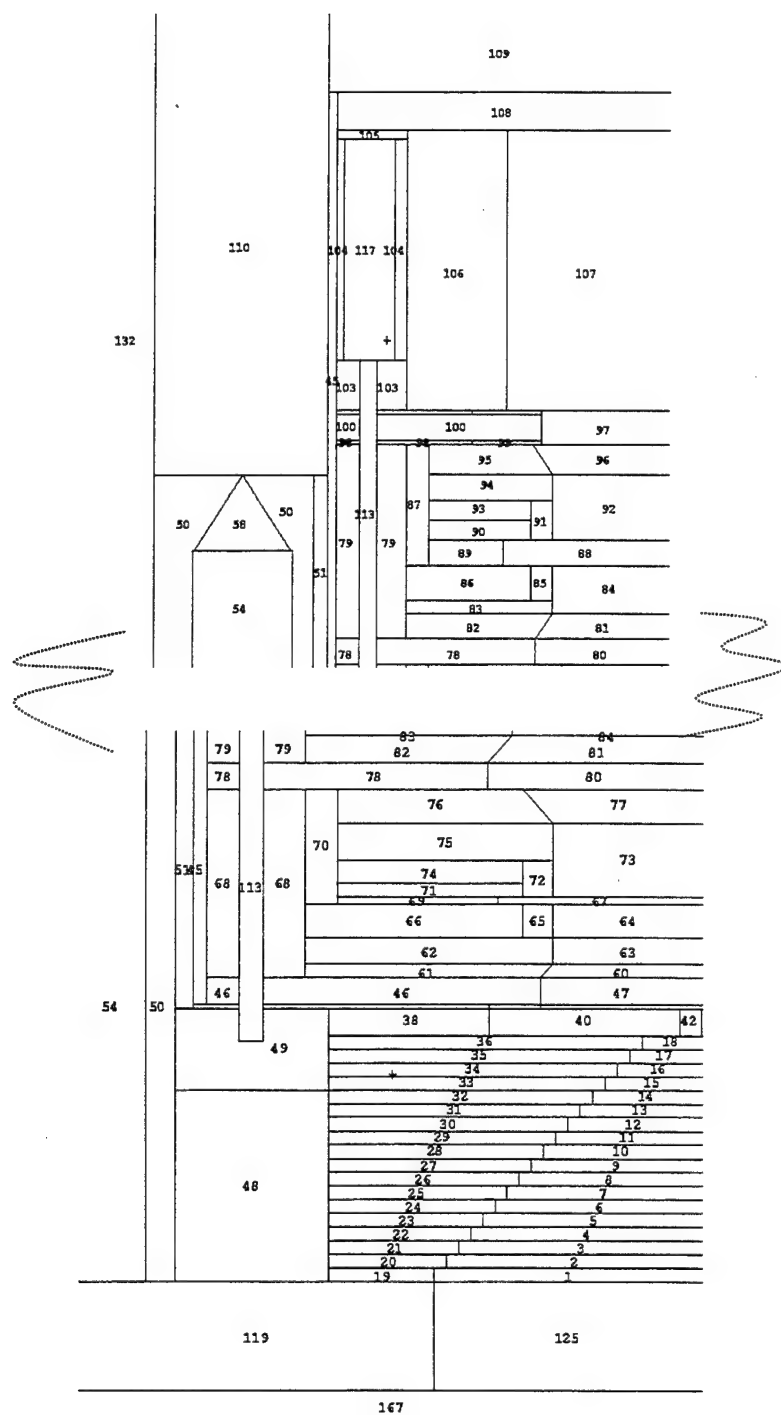


Figure 4. MCNPX Cell layout (partial) for CEASE [5,9] telescope (cell numbers refer to input file listed in Appendix 3). Drawings made with MCNP-VISED[7] editor.

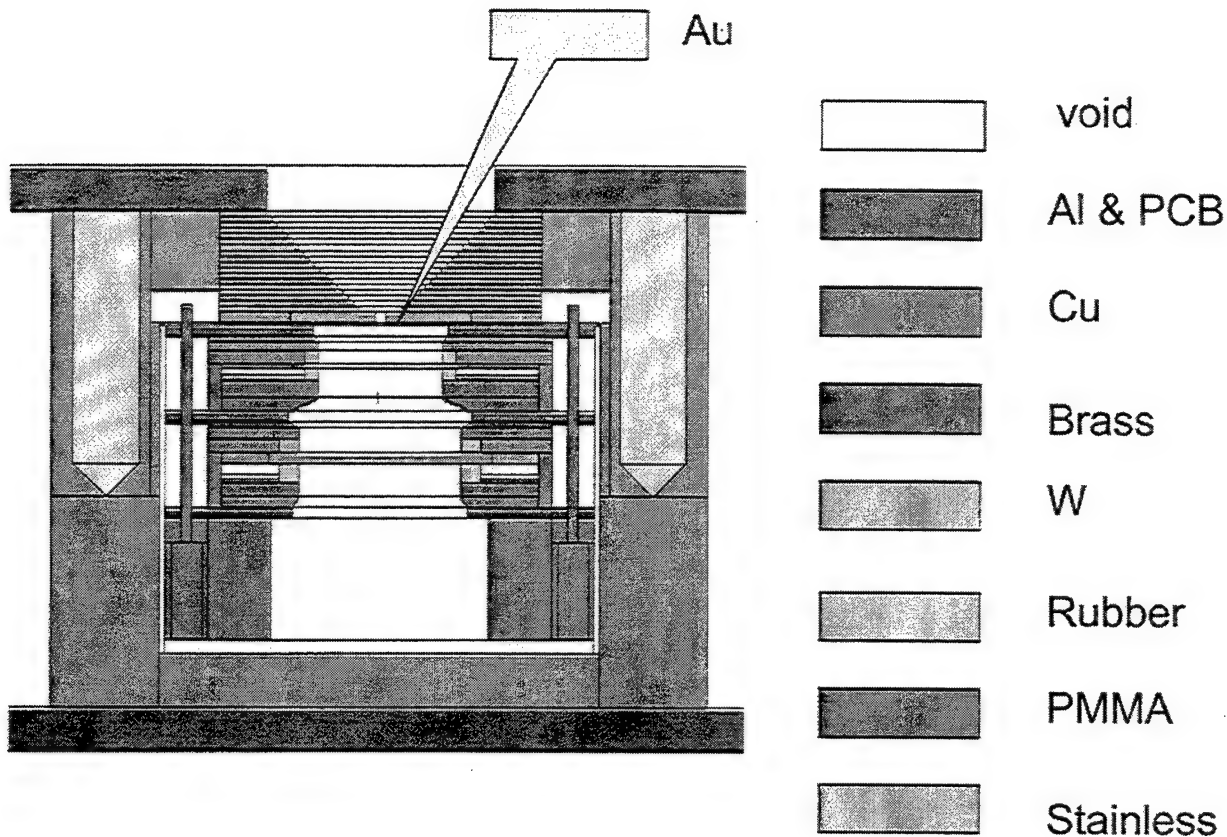


Figure 6. MCNPX Color-coded Materials Diagram for CEASE [5,9] telescope (color codes refer to input file listed in Appendix 3). Drawing made with MCNP-UISED[7] editor.

3.2.4. Particle Trajectory Analysis

Of particular importance to the AFRL/VSBXR space-borne sensor modeling effort is the ability to follow and analyze simulated individual particle tracks. The "ptrac" option in MCNPX provides this capability. The last record (`ptrac write=all file=asc`) in the input file causes MCNPX to write an ASCII format track file that records every event (scatter, absorption, surface crossing, escape, nuclear interaction) that occurs in every particle trajectory.

The following five pages (Figure 7) contain an annotated partial listing of the "ptrac" file for a single 300 MeV source proton history for the CEASE telescope-frame-case geometry. The file is configured so that every two lines (one consisting of integers and one consisting of floating point numbers) comprise an "event record". The events may be plane crossings, nuclear interactions, particle escape, particle absorptions, births of secondary, tertiary, *etc.* particles, deposits and withdrawals from the particle "bank", or particle deaths (energy below problem cut-off).

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Neutron #2									
3000	41	0	0	1	31				
-0.82689E-01	0.53800E+00	0.89817E+00	-0.44065E+00	-0.44065E+00	-0.89692E+00	0.70746E+00	0.10000E+01	0.56821E-03	
3000	42	71	153	1	75	1	31		
-0.10822E+00	0.53586E+00	0.84620E+00	-0.44065E+00	-0.44065E+00	-0.36941E-01	-0.89692E+00	0.70746E+00	0.55515E-02	
3000	43	107	153	1	74	1	31		
-0.14487E+00	0.53279E+00	0.77160E+00	-0.44065E+00	-0.44065E+00	-0.36941E-01	-0.89692E+00	0.70746E+00	0.12705E-01	
3000	44	70	153	1	71	0	31		
Gamma #1									
5000	72	114	153	1	31				
-0.62379E+00	0.49264E+00	-0.20320E+00	-0.44065E+00	-0.44065E+00	-0.89692E+00	0.70746E+00	0.10000E+01	0.10618E+00	
2033	72	1	3	1	0	0	31		
-0.62379E+00	0.49264E+00	-0.20320E+00	-0.44065E+00	-0.44065E+00	-0.36941E-01	-0.89692E+00	0.70746E+00	0.10618E+00	
4000	40	0	0	2	76	1	31		
-0.82689E-01	0.53800E+00	0.89817E+00	0.27157E+00	-0.53532E+00	-0.79980E+00	0.24890E-01	0.10000E+01	0.10281E+12	
5000	40	40000	3	2	76				
-0.78306E-01	0.52936E+00	0.88526E+00	0.27157E+00	-0.53532E+00	-0.79980E+00	0.24890E-01	0.10000E+01	0.10281E+12	
2033	40	12	4	2	76				
-0.78306E-01	0.52936E+00	0.88526E+00	0.27157E+00	-0.53532E+00	-0.79980E+00	0.24890E-01	0.10000E+01	0.10281E+12	
4000	39	0	0	2	76	1	31		
-0.82689E-01	0.53800E+00	0.89817E+00	-0.99950E+00	0.31429E-01	-0.31231E-02	0.28110E-01	0.10000E+01	0.77411E+03	
4000	39	39000	3	2	76	1	32		
-0.85178E-01	0.53808E+00	0.89816E+00	-0.58213E+00	0.80996E+00	0.71308E-01	0.89070E-02	0.10000E+01	0.77411E+03	
5000	39	39000	3	2	76	1	33		
-0.85557E-01	0.53861E+00	0.89821E+00	-0.58213E+00	0.80996E+00	0.89070E-02	0.89070E-02	0.10000E+01	0.77411E+03	
2033	39	12	5	2	76				
-0.85557E-01	0.53861E+00	0.89821E+00	-0.58213E+00	0.80996E+00	0.89070E-02	0.89070E-02	0.10000E+01	0.77411E+03	
3000	38	0	0	2	76	1	31		
-0.82689E-01	0.53800E+00	0.89817E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.59727E-03	
3000	39	71	115	2	75	1	31		
-0.13538E-01	0.61913E+00	0.84620E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.99285E-03	
3000	40	62	41	2	70	7	31		
0.80763E-01	0.72976E+00	0.77533E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.15323E-02	
3000	41	59	39	2	68	0	31		
0.13137E+00	0.78914E+00	0.73730E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.18218E-02	
3000	42	89	34	2	45	0	31		
0.27887E+00	0.96218E+00	0.62645E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.26656E-02	
3000	43	104	34	2	51	9	31		
0.29697E+00	0.98343E+00	0.61284E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.27692E-02	
4000	44	22	33	2	50	9	31		
0.32485E+00	0.10161E+01	0.59189E+00	0.58309E+00	0.68409E+00	-0.43821E+00	0.31260E+00	0.10000E+01	0.29287E-02	
4000	44	44000	1	2	50	9	32		
0.53994E+00	0.12685E+01	0.43024E+00	-0.81208E-01	0.35994E-01	0.99605E+00	0.16517E+00	0.10000E+01	0.41591E-02	
4000	44	44000	1	2	50	9	33		
0.53735E+00	0.12696E+01	0.46202E+00	-0.67508E+00	-0.46651E+00	0.57153E+00	0.14656E+00	0.10000E+01	0.42655E-02	
5000	44	44000	3	2	50	9	34		
0.33551E+00	0.11301E+01	0.63291E+00	-0.67508E+00	-0.46651E+00	0.57153E+00	0.14656E+00	0.10000E+01	0.52629E-02	
2033	44	12	6	2	50				
0.33551E+00	0.11301E+01	0.63291E+00	-0.67508E+00	-0.46651E+00	0.57153E+00	0.14656E+00	0.10000E+01	0.52629E-02	
3000	37	0	0	2	76	1	31		
-0.82689E-01	0.53800E+00	0.89817E+00	0.41373E-01	0.11914E-00	-0.99201E+00	0.67440E+00	0.10000E+01	0.57797E-03	

Figure 7. PTRAC file example (cont.)

-0.29389E+00	0.48782E+00	0.13510E+01	-0.40530E+00	-0.82322E-01	0.91047E+00	0.15050E+03	0.10000E+01	0.38200E-02
3000	44	92	24	9	4	44		
-0.30951E+00	0.48464E+00	0.13861E+01	-0.41261E+00	-0.84240E-01	0.90700E+00	0.15002E+03	0.10000E+01	0.40734E-02
3000	45	93	25	9	7	45		
-0.31302E+00	0.48393E+00	0.13938E+01	-0.41697E+00	-0.88668E-01	0.90459E+00	0.14957E+03	0.10000E+01	0.41293E-02
3000	46	94	25	9	0	46		
-0.57110E+00	0.42905E+00	0.19537E+01	-0.41708E+00	-0.89338E-01	0.90447E+00	0.14563E+03	0.10000E+01	0.82093E-02
3000	47	95	25	9	9	47		
-0.59983E+00	0.42289E+00	0.20160E+01	-0.41708E+00	-0.89338E-01	0.90447E+00	0.14563E+03	0.10000E+01	0.86682E-02
3000	48	96	26	9	2	53		
-0.71318E+00	0.39022E+00	0.22650E+01	-0.42296E+00	-0.14669E+00	0.89420E+00	0.13660E+03	0.10000E+01	0.10523E-01
3000	49	125	27	9	0	55		
-0.80279E+00	0.35902E+00	0.24543E+01	-0.42742E+00	-0.15491E+00	0.89068E+00	0.13388E+03	0.10000E+01	0.11972E-01
3000	50	126	27	9	2	56		
-0.11307E+01	0.24018E+00	0.31375E+01	-0.42742E+00	-0.15491E+00	0.89068E+00	0.13388E+03	0.10000E+01	0.17260E-01
3000	51	127	27	9	0	57		
-0.12069E+01	0.21257E+00	0.32963E+01	-0.42924E+00	-0.16210E+00	0.88852E+00	0.13146E+03	0.10000E+01	0.18489E-01
3000	52	128	27	9	2	58		
-0.15369E+01	0.87924E-01	0.39795E+01	-0.42924E+00	-0.16210E+00	0.88852E+00	0.13146E+03	0.10000E+01	0.23829E-01
3000	53	129	27	9	0	59		
-0.16136E+01	0.58963E-01	0.41383E+01	-0.43537E+00	-0.15394E+00	0.88699E+00	0.12940E+03	0.10000E+01	0.25070E-01
3000	54	130	27	9	2	60		
-0.19490E+01	-0.59618E-01	0.56174E+01	-0.43215E+00	-0.15472E+00	0.88699E+00	0.12940E+03	0.10000E+01	0.30455E-01
3000	55	117	115	9	0	62		
-0.20269E+01	-0.87192E-01	0.60304E+01	-0.43722E+00	-0.17055E+00	0.88843E+00	0.12707E+03	0.10000E+01	0.31707E-01
3000	56	115	115	9	2	63		
-0.23368E+01	-0.87192E-01	0.56174E+01	-0.43215E+00	-0.15472E+00	0.88843E+00	0.12707E+03	0.10000E+01	0.36757E-01
5000	57	117	115	9	0	66		
-0.25400E+01	-0.26986E+00	0.60304E+01	-0.43722E+00	-0.17055E+00	0.88303E+00	0.12154E+03	0.10000E+01	0.40058E-01
9000	57	1	12	9	0	66		
-0.25400E+01	-0.26986E+00	0.60304E+01	-0.43722E+00	-0.17055E+00	0.88303E+00	0.12154E+03	0.10000E+01	0.40058E-01

Proton #2 escapes

Figure 7. PTRAC file example (cont.)

End of history for this source particle

The first cluster of event records shown in Figure 7 describes the incidence of a 300 MeV proton (particle type label 9) normally incident on the copper collimator of the CEASE telescope. Several surface crossings (event code 3000) of a 300 MeV proton occur as the proton penetrates the collimator cells. The proton cross surfaces 29, 30, 31, 32, *etc.*, into cells 19, 20, 21, 22, *etc.* As indicated in the next event record cluster, the second line of the record contains the (X,Y,Z) coordinates of the event (crossing) point, trajectory (or particle velocity) direction cosines (U,V,W), particle energy (E in MeV), particle statistical weight (wt) (arises when/if variance reduction techniques such as particle splitting and "Russian roulette" are used), and finally, the time (sec) of occurrence.

The annotations shown in the next cluster point out the material designation, the integers corresponding to the material ("M" records) code of the input file. At the end of this cluster the source proton undergoes a nuclear interaction in cell #76 (brass annulus mounting for detector DFT) and is deposited in the particle bank. A neutron is "born" at the same coordinate point and eventually escapes (event code 5000) out the case side (x-plane #124). A second neutron appears from the same nuclear interaction (cell #76) and eventually escapes through the top of the case (z-plane #114). The next block of event records shows the origination of four gammas. Their trajectories are followed to their eventual escapes. The final block of records shows the trajectory of a secondary proton, created in the nuclear interaction described above, that travels along a nearly straight track (the small magnitudes of the deflections are evident from the small changes in the track direction cosines) and then escapes through x-plane #117 of the case. The event code 9000 signifies the end of the source particle history.

We have written a program that reads and interprets "ptrac" files. This program will eventually be modified to edit the file for events of particular interest to researchers at AFRL.

The MCNPX input files containing the geometry models for the CEASE telescope with and without the frame and case are now ready to be used in research both at ARCON and at AFRL.

4. Proton Transport Modeling - HEP Flight Sensor[6]

4.1 MCNPX HEP[6] Simulations

A new MCNPX geometry input file for the in-flight version of the HEP instrument was created from a complete set of manufacturing drawings supplied by Amptek, Inc.[6b] The drawings were highly detailed, enabling construction of a realistic MCNPX model. A drawing of the engineering version of HEP[6a] had also been available to us from earlier work that we had performed on a contract with Amptek, Inc.[10]. An MCNPX geometry description was also made for the earlier version. This was done for the following three reasons:

- 1) since several investigations had already been performed earlier using other codes, such as HETC, LAHET, ACCEPT and CYLTRAN on the relatively simple engineering model geometry, sufficient data existed to validate MCNPX Monte Carlo results for the engineering model, which can then be used for a "sanity check" on MCNPX results obtained for the final manufactured version.
- 2) the engineering version geometry is simple and requires little effort to write the MCNPX file.
- 3) displaying the two HEP models together effectively illustrates the contrast in detail level required for the description of the two versions.

The two MCNPX models are shown in Figure 8, (engineering model, Figure 8(a): manufacturing model, Figure 8(b)).

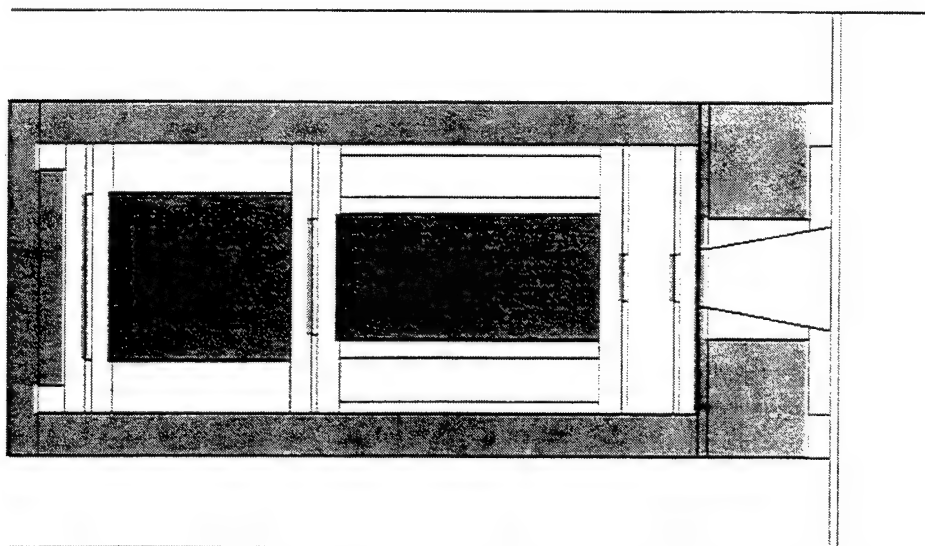


Figure 8(a). VISED rendering of MCNPX geometry/materials file for HEP flight sensor engineering model [6a].

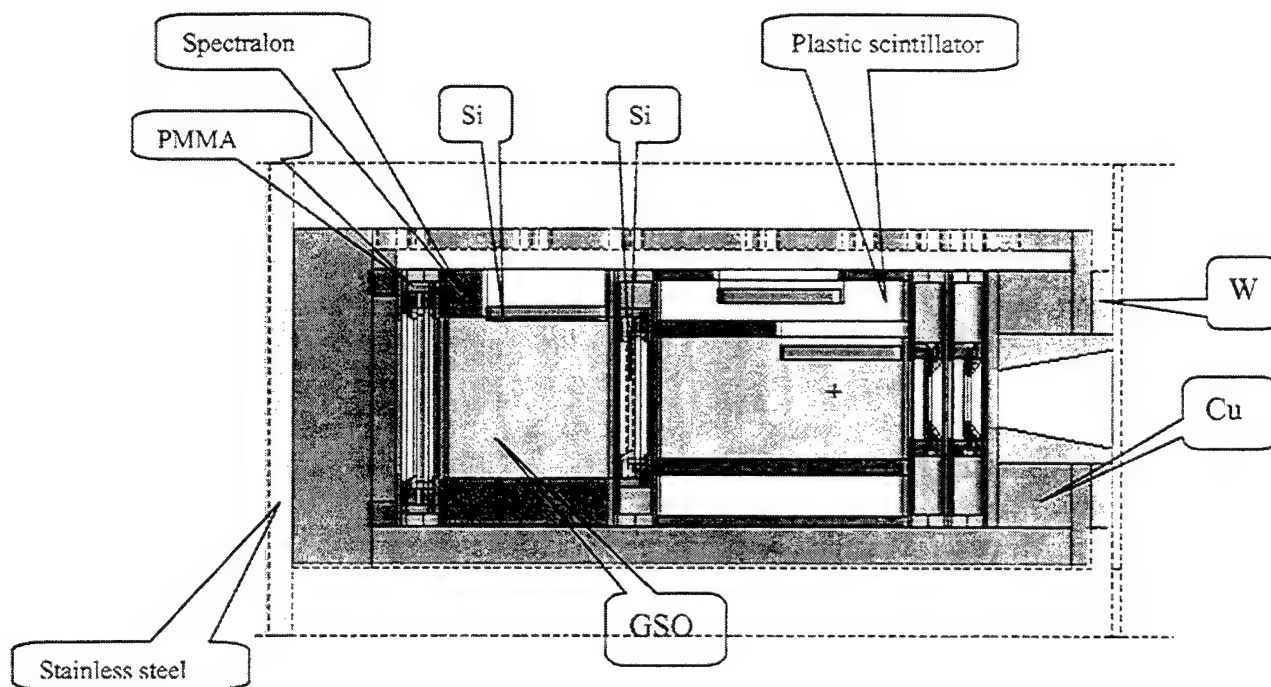
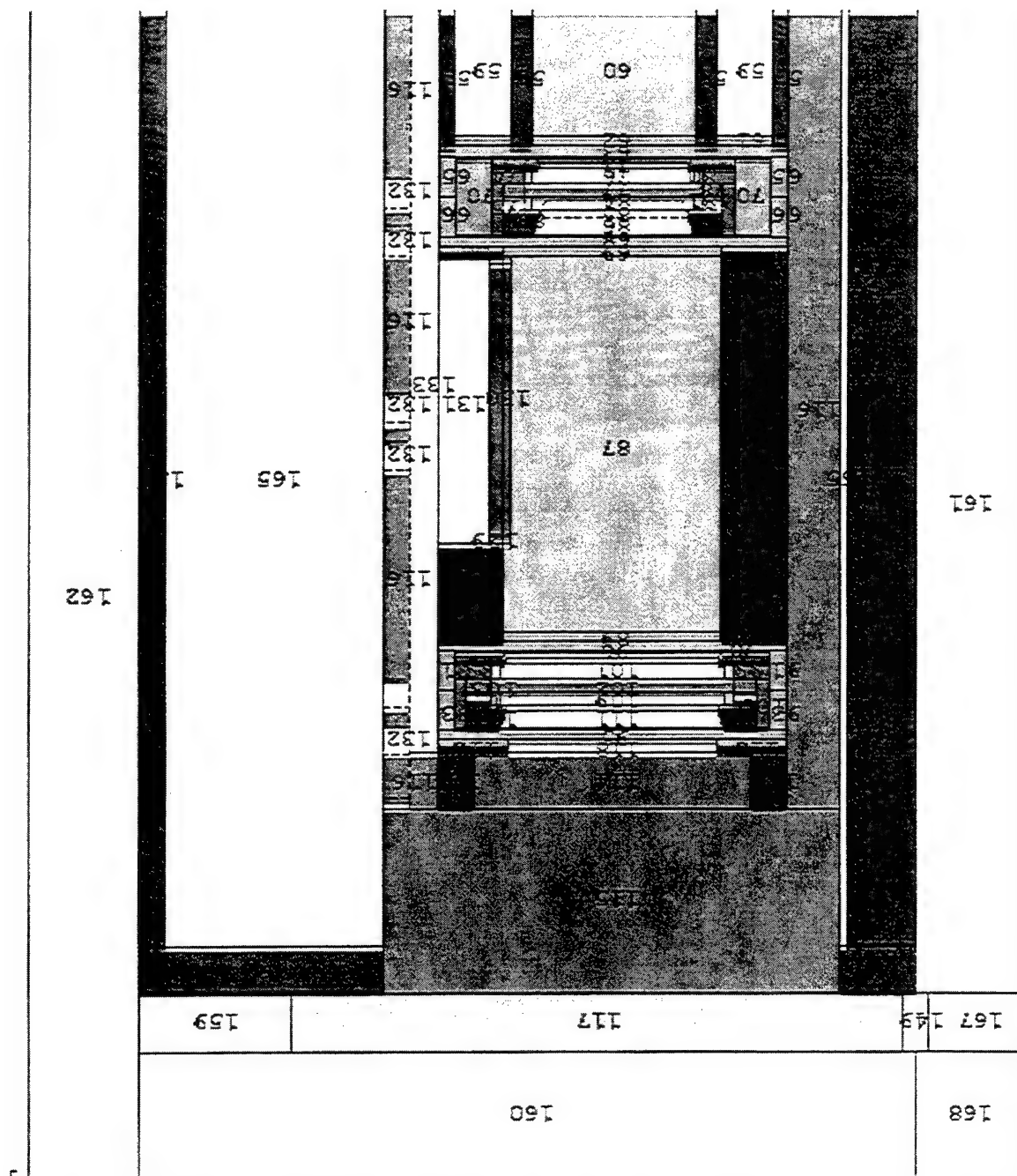


Figure 8(b). VISED rendering of MCNPX geometry/materials file for HEP flight sensor manufactured model [6b] (material color codes, differing from those shown in Figure 8(a), are automatically chosen by the VISED program)

The MCNPX input file corresponding to the HEP flight sensor depicted in Figure 8(b) is listed in Appendix 4. Several MCNPX runs were made to test the robustness of the geometry/materials file. The purpose was to uncover "holes" (errors) in the geometry specification. An efficient way to determine which, if any, cells are improperly defined in the input file is to run a large number of case histories for several source configurations and energies. Diagnostics appear in the MCNPX output when a particle has "lost its way". Armed with this information, we then used VISED to view the specific region of the geometry where the problem occurred, and made the appropriate corrections to the geometry records. The run file shown in Appendix 4 was used to simulate a 150 MeV proton disk source (3.0 cm radius) isotropically incident on a side of the aluminum case enclosing the sensor. For this and other diagnostic runs, we chose only to transport protons, as this would provide sufficient exercise of MCNPX to uncover geometry errors without unnecessary expenditure of computational effort.

Figures 9(a) and 9(b) are VISED partial views of the cell and surface structures, respectively, of the HEP flight sensor. The cell and surface numbers correspond to those given in the file listed in Appendix 4. While considerable detail is shown in these figures, the cell and surface label numbers are difficult, if not impossible, to decipher near the silicon wafer detectors. The model details of these areas can be more clearly viewed, as shown in the close-up cell drawings of silicon wafer detectors D3 (Figure 10) and D4 (Figure 11). Distinction between the electrically active and inactive areas of the silicon wafers is made by assignment of separate cells to the wafer portions. In detector D3, cell #77 represents the electrically active part, and cell #78 the inactive part. The corresponding cells for D4 are 102 and 103.

The MCNPX input files containing the geometry models for both the engineering and final versions of the HEP flight sensor will provide a useful research tool for AFRL and ARCON. We will assist in their implementation as well as provide guidance for model modification, where necessary, in the AFRL research effort.



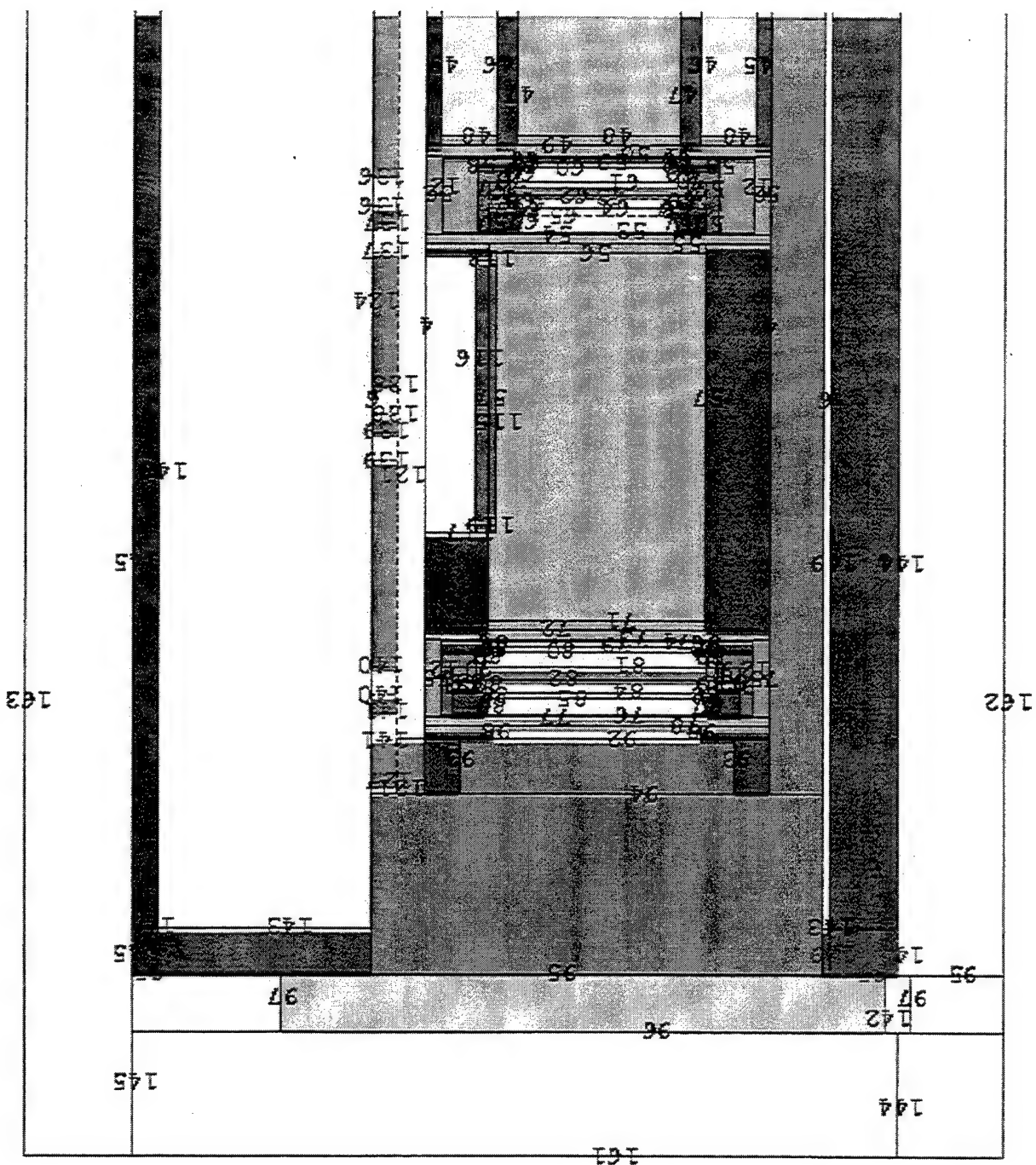
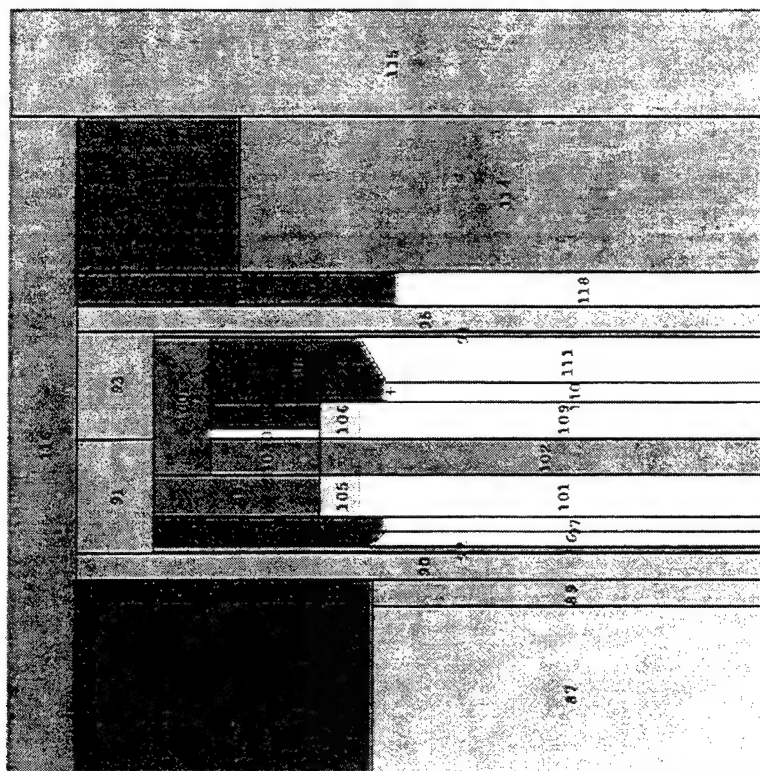
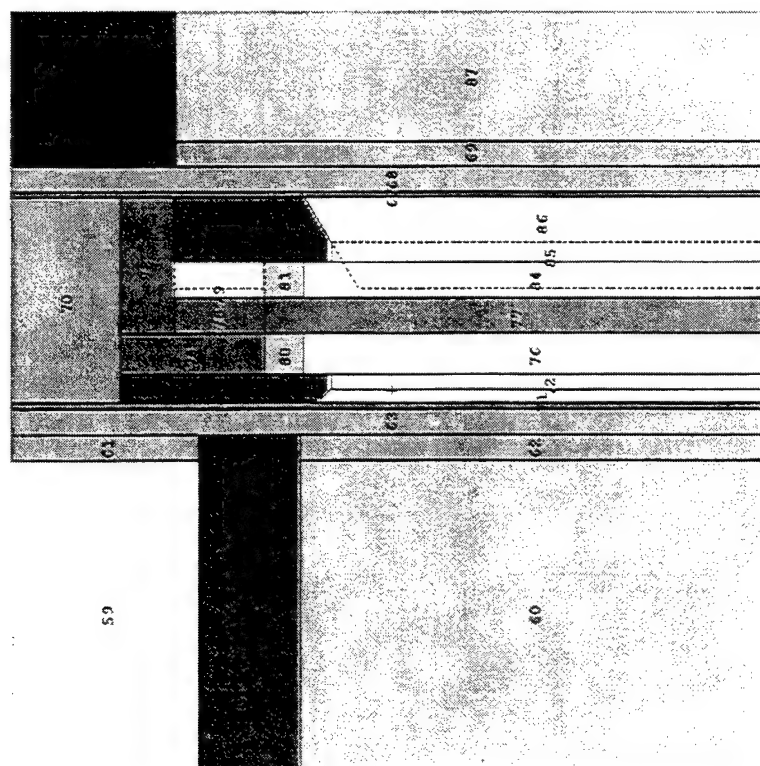


Figure 9(b). Partial (VISED) view of HEP (in-flight model) surface structure [6b].



5. Electron Transport Modeling

5.1 ACCEPT[2c] Simulations for the CEASE Telescope

Electron transport calculations were made with the ITS-ACCEPT[2c] code for the Compact Environmental Anomaly Sensor (CEASE) Telescope (Figure 1). As was stated in earlier sections, while MCNPX and its MCNP predecessors provide the most complete and efficient method for modeling problem geometries for the largest variety of transported particles, the ITS codes, written specifically to handle problems in coupled electron/photon transport, is more efficient for this application. The amount of effort required on the part of the modeler is perhaps more than is needed for the MCNPX models, however, if interest is limited to electron/photon transport, the economy gained in computational effort provides more than sufficient reason for using ITS-ACCEPT.

The modeling techniques of ACCEPT and MCNPX differ fundamentally. In working with the MCNP codes, the user constructs the bodies making up the whole (*e.g.* CEASE telescope) by first defining the surfaces that enclose it, and then specifying whether a point inside the body lies within (negative in the mathematical sense) or without (positive in the mathematical sense) a surface. In most instances the mathematical sense of a body with respect to a surface is obvious, however when it is not, one need only substitute the point coordinates into the equation for the surface. The mathematical sense is provided by the sign of the number that results from this substitution.

ACCEPT code modeling accomplishes essentially the same thing using the combinatorial geometry method. ACCEPT allows the user to choose from a collection of body types: arbitrarily oriented box(BOX); rectangular parallelepiped(RPP); sphere(SPH); right circular(RCC) and elliptical cylinders(REC); ellipsoid(ELL); truncated cone(TRC); wedge(WED); arbitrary polyhedron(ARB). The user specifies the set of cells required to describe in the modeled structure by specifying appropriate combinations of bodies, such as intersections, unions and differences.

Figure 12 is a drawing of the labeled bodies for the CEASE telescope. Our choice of the arrangement and number of bodies used for this modeling task is not unique. However, we chose to define a large number of bodies which could then be logically combined in the simplest of ways to form the material cells rather than taking unnecessary error risks associated with using a smaller number of bodies combined in logically complicated ways. For the CEASE telescope without the frame and case, a total of 205 bodies and 205 cells were defined. Figure 13 is the corresponding drawing of the labeled cells.

An ACCEPT input file for the CEASE telescope with frame and case is given in Appendix 5. The addition of the frame and case to the telescope description increased the total numbers of bodies and cells to 259. The order of the geometry input data is bodies first (*i.e.* RCC, TRC, RPP), then cells, formed by the logical addition and subtraction of bodies. This is followed by a block of data containing the cell volumes (optional) listed in the order in which the cells are labeled (*i.e.* Z1, Z2, *etc.*) and a block of data containing the cell material numbers, ordered as listed in the XGEN input file (Appendix 6). The XGEN program is run before ACCEPT to produce the cross section tables for all the materials of the problem. The input file sets up a 25000 case history ACCEPT run for a 9.9 MeV electron beam normally incident on the top of the

the aluminum case. The beam cross sectional area is a disk of radius 1.4 cm with its center located on the CEASE axis of symmetry.

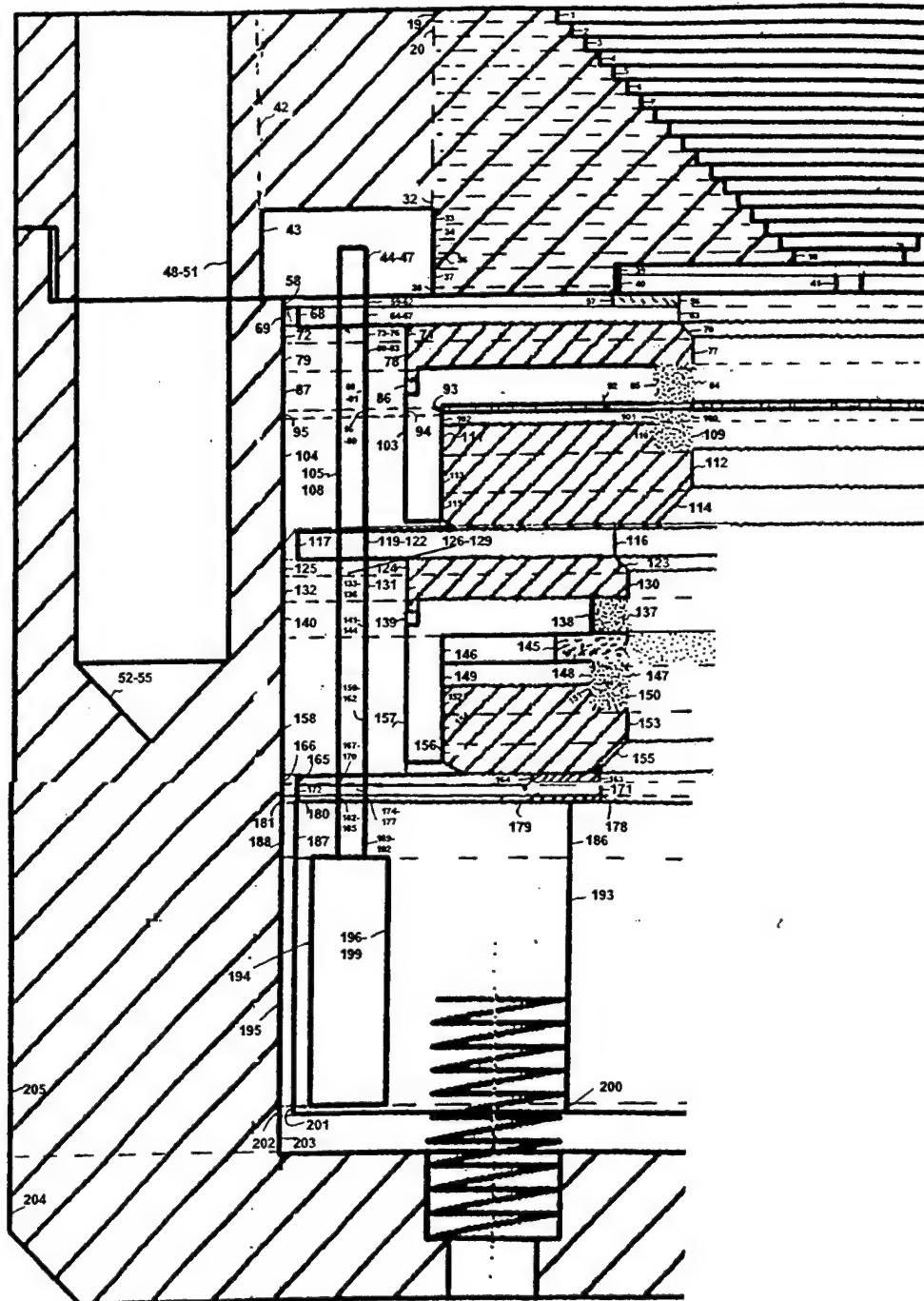


Figure 12. ACCEPT Body Definition Diagram for CEASE Telescope. The body labels correspond to those listed in the input file of Appendix 5.

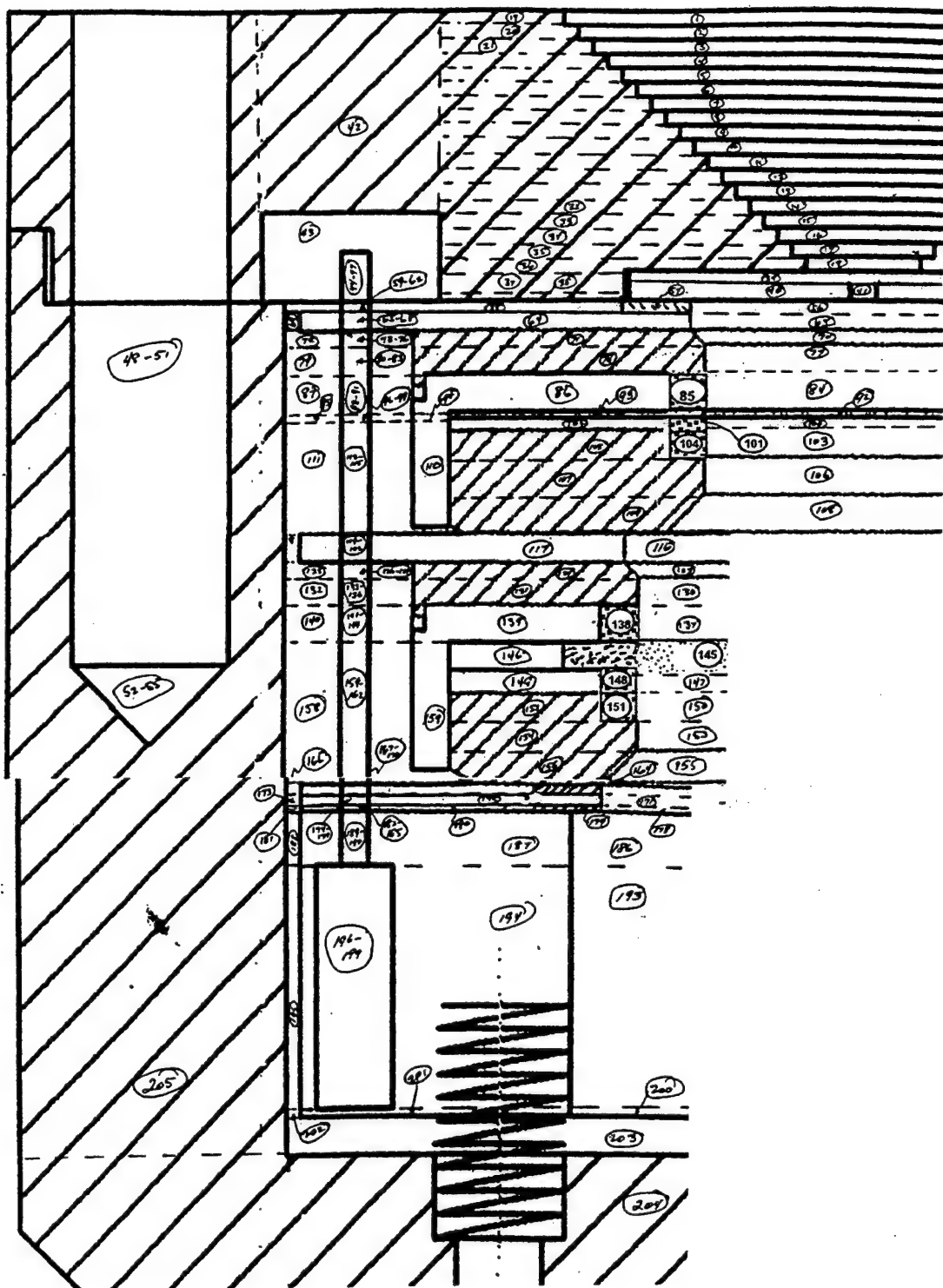


Figure 13. ACCEPT Cell Definition Diagram for CEASE Telescope. The cell labels correspond to those listed in the input file of Appendix 5 and the energy and charge deposition output listing of Appendix 7.

A partial listing of the ACCEPT output produced with the input file of Appendix 5, energy and charge deposition tables for the 259 cells, is given in Appendix 7.

Two sets of ACCEPT runs were made for the CEASE telescope: (1) telescope without frame and case; (2) telescope with frame and case. For each configuration, the runs were made for two beam energies, 9.9 and 6.0 MeV, with three incident obliquities, 0, 20, and 45° (w.r.t. telescope axis). The six disc sources for both configurations (1) and (2) were positioned above the telescope top (configuration 1) and above the case top (configuration 2) with the disc center located on the telescope axis. Additionally, one case was run for each configuration in which a disc source of 9.9 MeV electrons was assumed normally incident on the case bottom, again with the disc center located on the telescope axis of symmetry. The purpose of this investigation was to obtain a rough estimate of the extent to which the structure surrounding the telescope would affect the resulting energy and charge deposition within the telescope. The data shown in Table 1 provides some insight in this regard.

Table 1.

Total Energy and Charge Deposition in CEASE Telescope, Frame and Case
from 9.9 and 6.0 MeV Electron Beams Incident at 0, 20, and 45° through Telescope Top
and 0° through Case Bottom.

Electron beam Energy; Direction	instrument	Energy deposition			inst.w/o case
		case	total		
9.9 MeV normal	0.77382E+01	0.98642E+00	0.87247E+01	0.84380E+01	
9.9 MeV 20 deg	0.75919E+01	0.10310E+01	0.86229E+01	0.82880E+01	
9.9 MeV 45 deg	0.60965E+01	0.21474E+01	0.82439E+01	0.71770E+01	
6.0 MeV normal	0.45763E+01	0.95720E+00	0.55335E+01	0.54070E+01	
6.0 MeV 20 deg	0.46264E+01	0.86886E+00	0.54952E+01	0.53660E+01	
6.0 MeV 45 deg	0.37229E+01	0.16593E+01	0.53822E+01	0.46580E+01	
9.9 MeV rear norm	0.32799E+00	0.79876E+01	0.83156E+01	0.83330E+01	
	instrument	Charge deposition			inst.w/o case
		case	total		
9.9 MeV normal	0.90898E+00	0.19200E-01	0.92818E+00	0.90220E+00	
9.9 MeV 20 deg	0.85370E+00	0.53040E-01	0.90674E+00	0.87170E+00	
9.9 MeV 45 deg	0.66500E+00	0.11592E+00	0.78092E+00	0.73680E+00	
6.0 MeV normal	0.88382E+00	0.42400E-01	0.92622E+00	0.91440E+00	
6.0 MeV 20 deg	0.84804E+00	0.70440E-01	0.91848E+00	0.90540E+00	
6.0 MeV 45 deg	0.67350E+00	0.18088E+00	0.85438E+00	0.76990E+00	
9.9 MeV rear norm	0.95680E-01	0.51846E+00	0.61414E+00	0.85820E+00	

The effects on energy deposition of surrounding the telescope with the frame and case differ with electron beam energy. For the 9.9 MeV electron sources entering through the case top, the energy deposited in the telescope surrounded by the case varies from 92% to 85% of the amount of energy that would be deposited in the bare telescope, depending on incident angle. Because

the radius of the electron source "disk" is 1.4 cm, and the telescope aperture radius is ~ 0.5 cm, the area of the top plate directly exposed to the source is about 7 times larger than the aperture area. Therefore, depending on the direction of incidence, a significant fraction of the energy deposited in the case-frame structure is deposited in the top plate. This fraction varies from 85% (normal incidence) down to 38% (45° slant incidence) of the total energy deposited. For the 9.9 MeV electrons entering through the case bottom, the shielding effect of the case is dramatically increased. The energy deposited in the shielded telescope is approximately 4% of the energy that would be deposited by electrons entering the bare telescope through the bottom.

As might be expected, the shielding effect of the case is slightly greater for the 6.0 MeV electron sources, where energy deposited in the shielded telescope varies from 85% to 80% of the amount that would be deposited in the bare telescope. Of the total energy deposited in the case, 96% is deposited in the top plate (normal incidence) compared with 57% (45° slant incidence).

The results here indicate that realistic estimates of electron energy deposition in the CEASE telescope due to electron background in space can be made in a two-step process: (1) estimate the energy-angle distribution of electrons incident on the copper sheath encasing the CEASE telescope by running a set of simulations with electron beam sources with incident energies sampled from a "typical" space electron energy spectrum (the beam sources should be impinging on the case for a sufficient number of incident angles to permit simulation of arbitrary angular distributions by superposition); (2) utilize the energy-angle flux distributions of electrons obtained from step 1 to construct electron sources at the telescope exterior surface. Since the CEASE telescope assembly is mounted on the satellite exterior, only electrons incident on the side and top surfaces of the telescope need be considered.

5.2 CYLTRAN[2b] Simulation for the CEASE Telescope

Application of the CYLTRAN[2b] code is restricted to approximating problem geometries with total cylindrical symmetry. While this symmetry condition does not hold strictly for the CEASE telescope, if the stainless bolts and PMMA rods can be ignored, considerable economy of computational effort will result. CYLTRAN code runs generally require far less computer time than comparable ACCEPT runs, and the CYLTRAN geometry description file is usually about half as large as that required for ACCEPT and is easier to construct. These reasons justified our running the same source problem on the CEASE telescope with both programs. If equivalent, or near equivalent, results were to be obtained with both codes, then: (1) the likelihood is high that both codes are being used to properly simulate the electron/photon transport in the CEASE telescope; and (2) in situations where the effects of the case and frame can be ignored, CYLTRAN might be the preferable choice.

CYLTRAN was run for the 6.0 MeV normally incident electron source (1.4 cm radius disk source). The CYLTRAN energy and charge deposition results were compared with their ACCEPT counterparts. The direct comparison was made by dividing the CEASE geometry into 24 sections, *i.e.* clusters of ACCEPT and CYLTRAN cells describing the same geometry segments. These 24 sections, outlined with the colored lines, are labeled in Figure 14. Table 2 lists the energy deposition results from ACCEPT alongside the CYLTRAN data for the 24 sections. The CYLTRAN results closely track those obtained with ACCEPT. This was achieved with a CYLTRAN run time of 105 sec compared with 5900 sec for ACCEPT.

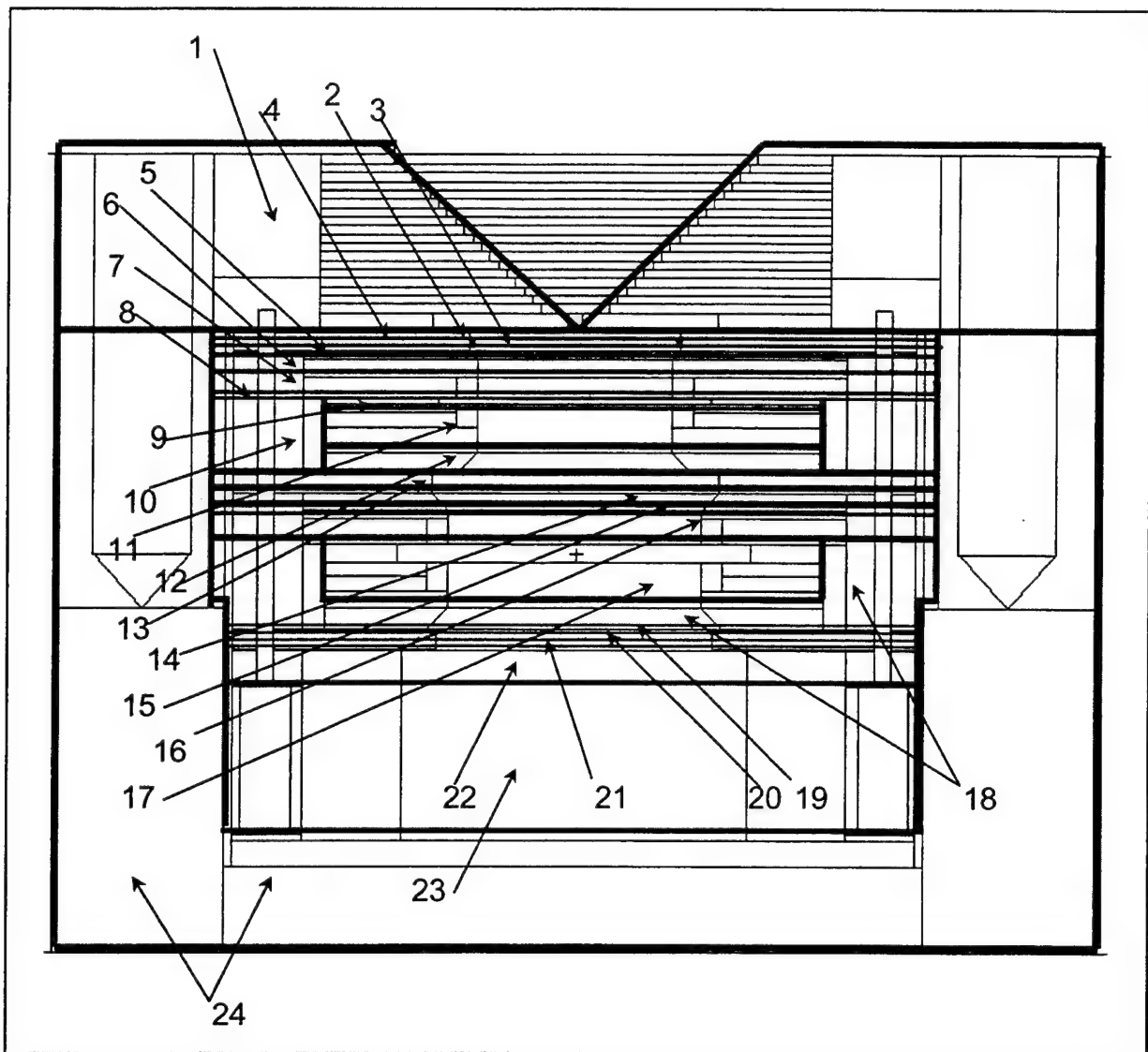


Figure 14. Cell clusters (24) comprising common definition of CEASE telescope geometry sections, regions outlined with (—) for both ACCEPT and CYLTRAN. ACCEPT and CYLTRAN energy deposition results for 6 MeV electron source, normally incident on top, are compared in Table 2.

Table 2. Comparison of ACCEPT and CYLTRAN Energy Deposition
Calculations for CEASE Telescope
(6 MeV electron source normally incident on top surface)

CELL (see Fig. 14)	ENERGY DEPOSITION (MeV)	
	ACCEPT	CYLTRAN
1	0.30264E+01	0.30172E+01
2	0.74210E-03	0.59331E-03
3	0.00000E+00	0.00000E+00
4	0.59560E-02	0.53913E-02
5	0.37657E-02	0.38671E-02
6	0.62859E-02	0.62188E-02
7	0.34803E-02	0.33354E-02
8	0.13232E-02	0.11061E-02
9	0.80120E-03	0.99519E-03
10	0.43820E-03	0.50560E-03
11	0.11522E-01	0.93524E-02
12	0.32310E-02	0.25409E-02
13	0.16880E-02	0.16472E-02
14	0.26630E-02	0.23131E-02
15	0.12930E-02	0.10255E-02
16	0.17821E-02	0.14628E-02
17	0.71571E-02	0.62222E-02
18	0.14257E-02	0.16183E-02
19	0.52870E-03	0.49061E-03
20	0.93790E-03	0.96860E-03
21	0.30940E-03	0.39563E-03
22	0.45900E-03	0.50587E-03
23	0.00000E+00	0.27694E-02
24	0.21214E+01	0.23492E+01
Total	0.54070E+01	0.54200E+01

6. Summary

During the period covered by this report, the technical progress achieved consisted of: (1) research, evaluation and selection of the available particle transport simulation programs for modeling the detection and measurement of space radiation by space-borne sensors; (2) construction of realistic (CEASE, HEP) sensor computer models and the performance of particle transport calculations; (3) analysis of transport simulation results, including single particle tracking; (4) transfer, including assistance and advice for implementation by the AFRL research personnel, of particle transport simulation technology to AFRL.

As indicated by the examples given in this report, several computer programs for particle transport simulation were applied to the modeling of the CEASE and HEP sensors. These programs are LAHET (proton source; proton, neutron, gamma, meson transport), ITS-ACCEPT and CYLTRAN (electron or gamma-photon sources; coupled electron/photon transport) and MCNPX (proton, electron, gamma-photon, neutron,....,alpha sources; 34 transportable particles/antiparticles). In addition, a preliminary version of a post-processor program for analysis of single particle histories from MCNPX was written. Shown in this report are several listings of input files, with geometry/materials drawings, for the various simulation programs, an example of (excerpt from) a track file analysis, and partial listings of code outputs.

We have also provided some explanation of the input parameter options available to the code user, with particular emphasis on the MCNPX code which, among all of the programs discussed, affords the highest degree of sensor geometry realism and the most flexible set of options to the researcher.

Based on our recommendations, the ITS codes, MCNP-Ver.4C, MCNPX-Ver.2.1.5, and MCNP-vised have been acquired by AFRL. We have made available to the sponsor copies of the geometry/materials input files for the CEASE and HEP for use with these codes. We look forward to continuing this research effort by providing simulation calculations and results to the sponsor, making code modifications where needed, and performing in an advisory capacity on the use of the codes. We will, as we already have, continually update our research on the latest in particle transport simulation program development by maintaining contact with the codes' authors.

7. References

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10. ARCON Corp. Contract No. 373, 1 Nov. 1995 – 31 March 1997.

APPENDIX 1

Annotated LAHET Input Data File for the CEASE Telescope, Frame and Case (surface, cell numbers refer to those shown in Figures 2 and 3, excepting frame and case)

lahet - CEASE Flight Sensor with Case geometry 300 MeV
In aperture normal incidence source - 200 protons

```

200,1,10,0,7*,1/
-1,-1/
1,0,0,7*/
300.,1.,1./
0,2,0/          $ Brass mat. 1
29.0,63.546,0.056594,0/
28.0,58.71,0.026252,0/
0,1,0/          $ Aluminum mat. 2
13.0,26.98,0.060275,0/
0,3,0/          $ Tungsten mat. 3
74.0,183.855,0.05602028,0/
28.0,58.71,0.006463106,0/
29.0,63.546,0.002559106,0/
0,1,0/          $ Gold mat. 4
79.0,196.9665,0.0577328,0/
0,9,0/          $ Micarta FR-4 mat. 5
8.0,15.9994,0.04438845,0/
14.0,28.0855,0.01374926,0/
20.0,40.08,0.005455978,0/
13.0,26.98,0.0036012,0/
5.0,10.81,0.002197474,0/
12.0,24.305,0.001897872,0/
11.0,22.9898,0.000987328,0/
26.0,55.847,0.000350574,0/
22.0,47.90,0.0001148818,0/
0,5,0/          $ Stainless mat. 6
25.0,54.9380,0.0057,0/
14.0,28.0855,0.00172,0/
24.0,51.996,0.01575,0/
28.0,58.71,0.00369,0/
26.0,55.847,0.06126,0/
0,6,0/          $ Conductive silicone elastomer mat. 7
14.0,28.0855,0.015175,0/
8.0,15.9994,0.0151619,0/
6.0,12.001,0.0303763,0/
1.0,1.0079,0.091092,0/
28.0,58.71,0.0288999,0/
47.0,107.868,0.0155626,0/
0.057272,2,0/   $ PMMA mat. 8
6.0,12.011,0.035795,0/
8.0,15.9994,0.014318,0/
0,1,0/          $ Silicon mat. 9
14.0,28.0855,0.04967,0/
0,2,0/          $ Copper alloy mat. 10
29.0,63.546,0.08412257,0/
52.0,127.6,0.0002105217,0/
C
C  CELLS
C
1  0          -1 29 -30 $ begin collimator aperture
2  0          -2 30 -31
3  0          -3 31 -32
4  0          -4 32 -33
5  0          -5 33 -34
6  0          -6 34 -35
7  0          -7 35 -36
8  0          -8 36 -37
9  0          -9 37 -38
10 0          -10 38 -39
11 0          -11 39 -40
12 0          -12 40 -41
13 0          -13 41 -42
14 0          -14 42 -43

```

15	0		-15	43	-44	
16	0		-16	44	-45	
17	0		-17	45	-46	
18	0		-18	46	-47	\$ end collimator aperture
19	10	-8.92	-21	1	29	-30 \$ copper collimator
20	10	-8.92	-21	2	30	-31
21	10	-8.92	-21	3	31	-32
22	10	-8.92	-21	4	32	-33
23	10	-8.92	-21	5	33	-34
24	10	-8.92	-21	6	34	-35
25	10	-8.92	-21	7	35	-36
26	10	-8.92	-21	8	36	-37
27	10	-8.92	-21	9	37	-38
28	10	-8.92	-21	10	38	-39
29	10	-8.92	-21	11	39	-40
30	10	-8.92	-21	12	40	-41
31	10	-8.92	-21	13	41	-42
32	10	-8.92	-21	14	42	-43
33	10	-8.92	-21	15	43	-44
34	10	-8.92	-21	16	44	-45
35	10	-8.92	-21	17	45	-46
36	10	-8.92	-21	18	46	-47
37	10	-8.92	-21	19	47	-48
38	10	-8.92	-21	19	48	-49
39	2	-2.7	-19	47	-48	\$ aluminum foil light shield
40	3	-18.0	-19	20	48	-49 \$ tungsten collimator disk
41	0		-104	49	19	-51 #111 #112 #113 #114 \$ void annulus
42	0		-20	48	-49	\$ void
43	4	-18.88	-19	53	49	-51 \$ gold annulus between tungsten and PCB
44	0		-53	49	-51	\$ void interior to gold annulus
45	0		-104	89	-95	51 \$ void annulus space next to copper case
46	5	-2.54	-89	53	51	-52 #111 #112 #113 #114 \$ PCB annulus
47	0		-53	51	-52	\$ void space at center of PCB annulus
48	10	-8.92	21	-22	29	-43 \$ copper collimator section
49	0		21	-22	43	-49 #111 #112 #113 #114 \$ void annulus in collimator
50	10	-8.92	22	-24	29	-106 #52 #53 #54 #55
						#56 #57 #58 #59 \$copper case section
51	10	-8.92	49	-106	104	-22 \$ copper case section
52	6	-8.0	29	-105	-25	\$ stainless bolt
53	6	-8.0	29	-105	-26	\$ stainless bolt
54	6	-8.0	29	-105	-27	\$ stainless bolt
55	6	-8.0	29	-105	-28	\$ stainless bolt
56	6	-8.0	105	-109		\$ stainless bolt tip
57	6	-8.0	105	-110		\$ stainless bolt tip
58	6	-8.0	105	-111		\$ stainless bolt tip
59	6	-8.0	105	-112		\$ stainless bolt tip
60	0		-55	52	-56	\$ void center of brass mounting for DFT
61	1	-8.53	55	52	-59	-56 \$ brass annulus mounting for DFT
62	1	-8.53	56	58	-59	-57 \$ brass annulus mounting for DFT
63	0		56	-58	-57	\$ void center of brass mounting for DFT
64	0		57	-58	-68	\$ void center of brass mounting for DFT
65	7	-7.4723	57	58	-61	-68 \$ rubber mounting spacer for DFT
66	8	-1.19	57	-59	61	-68 \$ PMMA spacer for DFT
67	3	-2.33	-67	68	-69	\$ DFT, electrically active part
68	0		59	-89	52	-72 #111 #112 #113 #114 \$ void
69	3	-2.33	67	-62	68	-69 \$ DFT, electrically inactive part
70	8	-1.19	-59	68	62	-72 \$ PMMA spacer for DFT
71	0		69	-70	61	-62 \$ void space between DFT and brass mounting
72	7	-7.4723	69	-107	58	-61 \$ rubber mounting spacer for DFT
73	0		69	-71	-58	\$ void center below DFT
74	1	-8.53	-107	70	-62	61 \$ brass annulus mounting for DFT
75	1	-8.53	107	-71	58	-62 \$ brass annulus mounting for DFT
76	1	-8.53	71	73	-72	-62 \$ brass annulus mounting for DFT
77	0		-73	71	-72	\$ void center below DFT
78	5	-2.54	75	72	-74	-89 #111 #112 #113 #114 \$ PCB annulus
79	0		59	-89	74	-91 #111 #112 #113 #114 \$ void
80	0		-75	72	-74	\$ void at center of PCB annulus
81	0		74	-77	-113	\$ void at center of brass mounting for DBT
82	1	-8.53	113	74	-77	-59 \$ brass annulus mounting for DBT
83	1	-8.53	77	-78	76	-59 \$ brass annulus mounting for DBT
84	0		77	-79	-76	\$ void at center of brass mounting for DBT
85	7	-7.4723	78	-79	76	-108 \$ rubber spacer for DBT
86	8	-1.19	78	-79	108	-59 \$ PMMA spacer for DBT
87	8	-1.19	79	-85	62	-59 \$ PMMA spacer for DBT
88	3	-2.33	79	-81	-80	\$ DBT, electrically active part
89	3	-2.33	79	-81	80	-62 \$ DBT, electrically inactive part

90	0		-62	81	-82	108	\$ void space between DBT and brass mounting
91	7	-7.4723	81	-83	76	-108	\$ rubber spacer for DBT
92	0		81	-84	-76		\$ void at center of brass mounting for DBT
93	1	-8.53	82	-83	108	-62	\$ brass annulus mounting for DBT
94	1	-8.53	83	-84	-62	76	\$ brass annulus mounting for DBT
95	1	-8.53	84	-85	-62	86	\$ brass annulus mounting for DBT
96	0		84	-85	-86		\$ void at center of brass mounting for DBT
97	0		85	-87	-93		\$ void at center of PCB annulus
98	0		88	85	-91	-89	#111 #112 #113 #114 \$ void annulus above PCB
99	4	-18.88	85	-91	-88	87	\$ gold spacer annulus on PCB
100	5	-2.54	-89	87	91	-92	#111 #112 #113 #114 \$ PCB annulus
101	0		92	-93	-89	88	#111 #112 #113 #114 \$ void annulus below PCB
102	4	-18.88	92	-93	-88	87	\$ gold spacer annulus below PCB
103	8	-1.19	59	-89	93	-101	#111 #112 #113 #114 \$ PMMA base annulus section
104	8	-1.19	101	59	-89	-102	#115 #116 #117 #118 \$ PMMA base annulus section
105	8	-1.19	59	-89	102	-94	\$ PMMA base annulus section
106	8	-1.19	-59	93	90	-94	\$ PMMA base annulus section
107	0		-90	93	-94		\$ void at center of base PMMA annulus
108	0		94	-95	-89		\$ void below base PMMA annulus
109	10	-8.92	95	-96	-104		\$ copper case bottom
110	10	-8.92	106	-96	104	-24	\$ copper case side/bottom
111	8	-1.19	103	-101	-63		\$ PMMA rod
112	8	-1.19	103	101	-64		\$ PMMA rod
113	8	-1.19	103	101	-65		\$ PMMA rod
114	8	-1.19	103	-101	-66		\$ PMMA rod
115	8	-1.19	101	102	-97		\$ PMMA rod
116	8	-1.19	101	102	-98		\$ PMMA rod
117	8	-1.19	101	102	-99		\$ PMMA rod
118	8	-1.19	101	102	-100		\$ PMMA rod
C							
C		outside case					
C							
119	2	-2.7	114	-29	117	-120	121 -124 #125 #139
120	2	-2.7	#140 #141 #142	\$ Al top plate			
121	2	-2.7	115	-116	117	-120	121 -124 #139
122	2	-2.7	#140 #141 #142	\$ Al bot plate			
123	2	-2.7	117	-118	29	-115	121 -124 \$ low x-side plate
124	2	-2.7	119	-120	29	-115	121 -124 \$ high x-side plate
125	0		121	-122	29	-115	118 -119 \$ low y-side plate
126	5	-2.54	123	-124	29	-115	118 -119 \$ high y-side plate
127	5	-2.54	114	-29	-1		\$ hole in case top for aperture
128	5	-2.54	96	-125	118	-119	122 -123 #142 #139 #140 #141 \$ micarta board
129	5	-2.54	126	-127	118	-119	122 -123 #142 #139 #140 #141 \$ micarta board
130	5	-2.54	128	-129	118	-119	122 -123 #142 #139 #140 #141 \$ micarta board
131	5	-2.54	130	-131	118	-119	122 -123 #142 #139 #140 #141 \$ micarta board
132	0		132	-133	118	-119	122 -123 #142 #139 #140 #141 \$ micarta board
133	0		134	-135	118	-119	122 -123 #142 #139 #140 #141 \$ micarta board
134	0		29	-96	118	-119	122 -123 24 #139 #140 #141 #142
135	0		\$	Void between top Al plate and top micarta board; excludes corner bolts and telescope			
136	0		0	#139	#140	#141	#142 #143 #149 #155 #161
137	0		125	-126	118	-119	122 -123 \$ void between boards
138	0		127	-128	118	-119	122 -123 \$ void between boards
139	0		0	#139	#140	#141	#142 #145 #151 #157 #163
140	0		129	-130	118	-119	122 -123 \$ void between boards
141	0		0	#139	#140	#141	#142 #146 #152 #158 #164
142	0		131	-132	118	-119	122 -123 \$ void between boards
143	0		0	#139	#140	#141	#142 #147 #153 #159 #165
144	0		133	-134	118	-119	122 -123 \$ void between boards
145	0		0	#139	#140	#141	#142 #148 #154 #160 #166
146	0		135	-115	118	-119	122 -123 \$ void between boards
147	6	-8.0	139	-136	-116	114	\$ Stainless corner bolt (case)
148	6	-8.0	140	-137	-116	114	\$ Stainless corner bolt (case)
149	6	-8.0	141	-138	-116	114	\$ Stainless corner bolt (case)
150	6	-8.0	142	-139	-116	114	\$ Stainless corner bolt (case)
151	8	-1.19	136	-140	#139	125	-126 \$ PMMA spacer wrapped around stainless corner bolt
152	8	-1.19	136	-140	#139	127	-128 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	136	-140	#139	129	-130 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	136	-140	#139	131	-132 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	136	-140	#139	133	-134 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	136	-140	#139	135	-115 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	137	-141	#140	125	-126 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	137	-141	#140	127	-128 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	137	-141	#140	129	-130 \$ PMMA spacer wrapped around stainless corner bolt
	8	-1.19	137	-141	#140	131	-132 \$ PMMA spacer wrapped around stainless corner bolt

```

153 8 -1.19 137 -141 #140 133 -134 $ PMMA spacer wrapped around stainless corner bolt
154 8 -1.19 137 -141 #140 135 -115 $ PMMA spacer wrapped around stainless corner bolt
155 8 -1.19 138 -142 #141 125 -126 $ PMMA spacer wrapped around stainless corner bolt
156 8 -1.19 138 -142 #141 127 -128 $ PMMA spacer wrapped around stainless corner bolt
157 8 -1.19 138 -142 #141 129 -130 $ PMMA spacer wrapped around stainless corner bolt
158 8 -1.19 138 -142 #141 131 -132 $ PMMA spacer wrapped around stainless corner bolt
159 8 -1.19 138 -142 #141 133 -134 $ PMMA spacer wrapped around stainless corner bolt
160 8 -1.19 138 -142 #141 135 -115 $ PMMA spacer wrapped around stainless corner bolt
161 8 -1.19 139 -143 #142 125 -126 $ PMMA spacer wrapped around stainless corner bolt
162 8 -1.19 139 -143 #142 127 -128 $ PMMA spacer wrapped around stainless corner bolt
163 8 -1.19 139 -143 #142 129 -130 $ PMMA spacer wrapped around stainless corner bolt
164 8 -1.19 139 -143 #142 131 -132 $ PMMA spacer wrapped around stainless corner bolt
165 8 -1.19 139 -143 #142 133 -134 $ PMMA spacer wrapped around stainless corner bolt
166 8 -1.19 139 -143 #142 135 -115 $ PMMA spacer wrapped around stainless corner bolt
167 0 144 -114 146 -147 148 -149 $ exterior void region (1 cm thick) above top z plate
168 0 116 -145 146 -147 148 -149 $ exterior void region(1 cm thick) below bottom z plate
169 0 146 -117 148 -149 114 -145 $ exterior void region (1 cm thick)outside lower x plate
170 0 120 -147 148 -149 114 -145 $ exterior void region(1 cm thick) outside upper x plate
171 0 117 -120 148 -121 114 -145 $ exterior void region(1 cm thick)outside lower y plate
172 0 117 -120 124 -149 114 -145 $ exterior void region(1 cm thick)outside upper y plate
173 0 -144:-148: 145:149:-146:147 $ escape region

```

```

1  cz  0.5334
2  cz  0.5080
3  cz  0.4826
4  cz  0.4572
5  cz  0.4318
6  cz  0.4064
7  cz  0.3810
8  cz  0.3556
9  cz  0.3302
10 cz  0.3048
11 cz  0.2794
12 cz  0.2540
13 cz  0.2286
14 cz  0.2032
15 cz  0.1778
16 cz  0.1524
17 cz  0.1270
18 cz  0.1016
19 cz  0.4191
20 cz  0.02286
21 cz  0.750711
22 cz  1.06680
24 cz  1.5240
25 c/z  1.27 0.00 0.143111
26 c/z  0.00 1.27 0.143111
27 c/z -1.27 0.00 0.143111
28 c/z  0.00 -1.27 0.143111
29 pz  0.00000
30 pz  0.02540
31 pz  0.05080
32 pz  0.07620
33 pz  0.1016
34 pz  0.1270
35 pz  0.1524
36 pz  0.1778
37 pz  0.2032
38 pz  0.2286
39 pz  0.2540
40 pz  0.2794
41 pz  0.3048
42 pz  0.3302
43 pz  0.3556
44 pz  0.3810
45 pz  0.4064
46 pz  0.4318
47 pz  0.4572
48 pz  0.4581
49 pz  0.5080
51 pz  0.51652
52 pz  0.56732
53 cz  0.3111
55 kz  0.87842 1.0 -1
56 pz  0.592208
57 pz  0.64199

```

58 cz 0.28622
59 cz 0.8000
61 cz 0.34844
62 cz 0.73422
63 c/z 0.9087555 0.00 0.0248889
64 c/z 0.00 0.9087555 0.0248889
65 c/z -0.9087555 0.00 0.0248889
66 c/z 0.00 -0.9087555 0.0248889
67 cz 0.4021
68 pz 0.704212
69 pz 0.719212
70 pz 0.744212
71 pz 0.856101
72 pz 0.918323
73 kz 0.569883 1.0 +1
74 pz 0.969123
75 cz 0.423111
76 cz 0.373111
77 pz 1.019123
78 pz 1.043789
79 pz 1.113477
80 cz 0.518942
81 pz 1.163477
82 pz 1.203477
83 pz 1.243477
84 pz 1.293477
85 pz 1.352774
86 kz 0.920366 1.0 +1
87 cz 0.4064
88 cz 0.6096
89 cz 1.001777
90 cz 0.5080
91 pz 1.360394
92 pz 1.41119
93 pz 1.41881
94 pz 1.971965
95 pz 2.046631
96 pz 2.29552
97 c/z 0.9087555 0.00 0.0734222
98 c/z 0.00 0.9087555 0.0734222
99 c/z -0.9087555 0.00 0.0734222
100 c/z 0.00 -0.9087555 0.0734222
101 pz 1.518365
102 pz 1.953921
103 pz 0.448143
104 cz 1.027288
105 pz 1.142666
106 pz 1.29200
107 pz 0.787657
108 cz 0.43533
109 k/z 1.27 0.00 1.292 0.8575536 -1
110 k/z 0.00 1.27 1.292 0.8575536 -1
111 k/z -1.27 0.00 1.292 0.8575536 -1
112 k/z 0.00 -1.27 1.292 0.8575536 -1
113 kz 1.392234 1.0 -1
114 pz -2.2032
115 pz 7.5565
116 pz 8.1661
117 px -2.54
118 px -2.3368
119 px 7.4168
120 px 7.62
121 py -2.54
122 py -2.3368
123 py 7.4168
124 py 7.62
125 pz 2.454275
126 pz 3.137535
127 pz 3.296285
128 pz 3.979545
129 pz 4.138295
130 pz 4.821555
131 pz 4.980305
132 pz 5.663565
133 pz 5.822315
134 pz 6.505575

APPENDIX 2

Energy Deposition Audits (partial listing of HTAPE output) For 300 MeV Proton Beam Source Entering CEASE through Telescope Aperture (cell numbers refer to cells shown in Figure 3)

listing of card input

```
1 300 MeV Mass-Energy Deposition Audit 200 histories
2 12/27/99 CEASE - normal beam on front face with case
3 6,0,0,0,0,109/
4 19,20,21,22,23,24,25,26,27,28,29,30,31,32,33,34,
5 35,36,37,38,39,40,43,46,48,50,
6 51,52,53,54,55,56,57,58,59,61,62,65,66,
7 67,69,70,72,74,75,76,78,82,
8 83,85,86,87,88,89,91,93,94,95,
9 99,103,105,106,109,110,
10 111,112,113,114,115,116,117,118,
11 119,120,121,122,123,124,126,127,128,129,
12 130,131,139,140,141,142,143,144,145,146,
13 147,148,149,150,151,152,153,154,155,156,
14 160,161,162,163,164,165,166/
15 /
```

1 case 1

1 case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

energy deposition in cell 31

	time total
coulomb loss h-1	7.96533D-02 0.172
coulomb loss pi+-	0.00000D+00 0.000
coulomb loss mu+-	0.00000D+00 0.000
coulomb loss K+-	0.00000D+00 0.000
coulomb loss pbar	0.00000D+00 0.000
coulomb loss h-2	0.00000D+00 0.000
coulomb loss h-3	0.00000D+00 0.000
coulomb loss he-3	0.00000D+00 0.000
coulomb loss he-4	0.00000D+00 0.000
nuclear recoil	0.00000D+00 0.000
excitation	0.00000D+00 0.000
pi0 decay gammas	0.00000D+00 0.000
kin. eng. of e+,e-	0.00000D+00 0.000
positron mass	0.00000D+00 0.000
kin. eng. of muons	0.00000D+00 0.000
mu+ mass	0.00000D+00 0.000
mu- mass	0.00000D+00 0.000
total deposition	7.96533D-02 0.172

1 case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

energy deposition in cell 32

	time total
coulomb loss h-1	1.61736D-01 0.110
coulomb loss pi+-	0.00000D+00 0.000

coulomb loss mu+-	0.00000D+00	0.000
coulomb loss K+-	0.00000D+00	0.000
coulomb loss pbar	0.00000D+00	0.000
coulomb loss h-2	0.00000D+00	0.000
coulomb loss h-3	0.00000D+00	0.000
coulomb loss he-3	0.00000D+00	0.000
coulomb loss he-4	0.00000D+00	0.000
nuclear recoil	0.00000D+00	0.000
excitation	0.00000D+00	0.000
pi0 decay gammas	0.00000D+00	0.000
kin. eng. of e+,e-	0.00000D+00	0.000
positron mass	0.00000D+00	0.000
kin. eng. of muons	0.00000D+00	0.000
mu+ mass	0.00000D+00	0.000
mu- mass	0.00000D+00	0.000
total deposition	1.61736D-01	0.110

1 case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

energy deposition in cell 33

	time total	
coulomb loss h-1	3.02573D-01	0.082
coulomb loss pi+-	0.00000D+00	0.000
coulomb loss mu+-	0.00000D+00	0.000
coulomb loss K+-	0.00000D+00	0.000
coulomb loss pbar	0.00000D+00	0.000
coulomb loss h-2	0.00000D+00	0.000
coulomb loss h-3	0.00000D+00	0.000
coulomb loss he-3	0.00000D+00	0.000
coulomb loss he-4	0.00000D+00	0.000
nuclear recoil	0.00000D+00	0.000
excitation	0.00000D+00	0.000
pi0 decay gammas	0.00000D+00	0.000
kin. eng. of e+,e-	0.00000D+00	0.000
positron mass	0.00000D+00	0.000
kin. eng. of muons	0.00000D+00	0.000
mu+ mass	0.00000D+00	0.000
mu- mass	0.00000D+00	0.000
total deposition	3.02573D-01	0.082

case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

energy deposition in cell 34

	time total	
coulomb loss h-1	5.39551D-01	0.357
coulomb loss pi+-	0.00000D+00	0.000
coulomb loss mu+-	0.00000D+00	0.000
coulomb loss K+-	0.00000D+00	0.000
coulomb loss pbar	0.00000D+00	0.000
coulomb loss h-2	0.00000D+00	0.000
coulomb loss h-3	0.00000D+00	0.000
coulomb loss he-3	0.00000D+00	0.000
coulomb loss he-4	0.00000D+00	0.000
nuclear recoil	9.41896D-03	1.000
excitation	6.83015D-04	1.000
pi0 decay gammas	0.00000D+00	0.000
kin. eng. of e+,e-	0.00000D+00	0.000
positron mass	0.00000D+00	0.000
kin. eng. of muons	0.00000D+00	0.000
mu+ mass	0.00000D+00	0.000
mu- mass	0.00000D+00	0.000
total deposition	5.49653D-01	0.368

1 case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

	time total	
coulomb loss h-1	4.29619D-01	0.039
coulomb loss pi+-	0.00000D+00	0.000
coulomb loss mu+-	0.00000D+00	0.000
coulomb loss K+-	0.00000D+00	0.000
coulomb loss pbar	0.00000D+00	0.000
coulomb loss h-2	0.00000D+00	0.000
coulomb loss h-3	0.00000D+00	0.000
coulomb loss he-3	0.00000D+00	0.000
coulomb loss he-4	0.00000D+00	0.000
nuclear recoil	0.00000D+00	0.000
excitation	0.00000D+00	0.000
pi0 decay gammas	0.00000D+00	0.000
kin. eng. of e+,e-	0.00000D+00	0.000
positron mass	0.00000D+00	0.000
kin. eng. of muons	0.00000D+00	0.000
mu+ mass	0.00000D+00	0.000
mu- mass	0.00000D+00	0.000
total deposition	4.29619D-01	0.039

1 case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

energy deposition in cell 36

	time total	
coulomb loss h-1	5.21322D-01	0.101
coulomb loss pi+-	0.00000D+00	0.000
coulomb loss mu+-	0.00000D+00	0.000
coulomb loss K+-	0.00000D+00	0.000
coulomb loss pbar	0.00000D+00	0.000
coulomb loss h-2	0.00000D+00	0.000
coulomb loss h-3	0.00000D+00	0.000
coulomb loss he-3	0.00000D+00	0.000
coulomb loss he-4	0.00000D+00	0.000
nuclear recoil	0.00000D+00	0.000
excitation	0.00000D+00	0.000
pi0 decay gammas	0.00000D+00	0.000
kin. eng. of e+,e-	0.00000D+00	0.000
positron mass	0.00000D+00	0.000
kin. eng. of muons	0.00000D+00	0.000
mu+ mass	0.00000D+00	0.000
mu- mass	0.00000D+00	0.000
total deposition	5.21322D-01	0.101

1 case no. 1 option no. 6

300 MeV Mass-Energy Deposition Audit 200 histories
12/27/99 CEASE - normal beam on front face with case

total energy deposition

	time total	
coulomb loss h-1	2.66593D+01	0.046
coulomb loss pi+-	0.00000D+00	0.000
coulomb loss mu+-	0.00000D+00	0.000
coulomb loss K+-	0.00000D+00	0.000
coulomb loss pbar	0.00000D+00	0.000
coulomb loss h-2	3.32249D-01	0.963
coulomb loss h-3	0.00000D+00	0.000
coulomb loss he-3	0.00000D+00	0.000
coulomb loss he-4	4.07842D-02	0.954
nuclear recoil	1.42414D-01	0.331
excitation	5.15510D-01	0.411
pi0 decay gammas	0.00000D+00	0.000

kin. eng. of e+,e-	0.00000D+00	0.000
positron mass	0.00000D+00	0.000
kin. eng. of muons	0.00000D+00	0.000
mu+ mass	0.00000D+00	0.000
mu- mass	0.00000D+00	0.000
total deposition	2.76903D+01	0.053

case no. 1 completed

execution time= 3.49 seconds

APPENDIX 3 **MCNPX Input File** **For**

300 MeV Proton Beam Source Entering CEASE through Telescope Aperture
(cell and surface numbers refer to cells and surfaces shown in Figures 4 and 5, respectively)

Test for protons CEASE Flight Sensor with Case for MCNPX

C

C Proton, neutron, muon, pion, photon

C transport - 300 MeV proton normal beam on top of case

C

C Cells

C

c begin collimator aperture

1 0 -1 29 -30

2 0 -2 30 -31

3 0 -3 31 -32

4 0 -4 32 -33

5 0 -5 33 -34

6 0 -6 34 -35

7 0 -7 35 -36

8 0 -8 36 -37

9 0 -9 37 -38

10 0 -10 38 -39

11 0 -11 39 -40

12 0 -12 40 -41

13 0 -13 41 -42

14 0 -14 42 -43

15 0 -15 43 -44

16 0 -16 44 -45

17 0 -17 45 -46

18 0 -18 46 -47

c end of collimator aperture

c

c copper collimator, cells 19-38

19 9 -8.92 -21 1 29 -30

20 9 -8.92 -21 2 30 -31

21 9 -8.92 -21 3 31 -32

22 9 -8.92 -21 4 32 -33

23 9 -8.92 -21 5 33 -34

24 9 -8.92 -21 6 34 -35

25 9 -8.92 -21 7 35 -36

26 9 -8.92 -21 8 36 -37

27 9 -8.92 -21 9 37 -38

28 9 -8.92 -21 10 38 -39

29 9 -8.92 -21 11 39 -40

30 9 -8.92 -21 12 40 -41

31 9 -8.92 -21 13 41 -42

32 9 -8.92 -21 14 42 -43

33 9 -8.92 -21 15 43 -44

34 9 -8.92 -21 16 44 -45

35 9 -8.92 -21 17 45 -46

36 9 -8.92 -21 18 46 -47

37 9 -8.92 -21 19 47 -48

38 9 -8.92 -21 19 48 -49

c end of copper collimator

c

c aluminum foil light shield

39 2 -2.7 -19 47 -48

c tungsten collimator disk

40 3 -18.0 -19 20 48 -49

c void annulus

41 0 -104 49 19 -51 #111 #112 #113 #114

c void

42 0 -20 48 -49

c gold annulus between tungsten and PCB

43 4 -18.88 -19 53 49 -51

c void interior to gold annulus

44 0 -53 49 -51

c void annulus space next to copper case

45 0 -104 89 -95 51

c PCB annulus

46 2 -2.7 -89 53 51 -52 #111 #112 #113 #114

```

c    void space at center of PCB annulus
47  0 -53 51 -52
c    copper collimator section
48  9 -8.92 21 -22 29 -43
c    void annulus in collimator
49  0 21 -22 43 -49 #111 #112 #113 #114
c    copper case section
50  9 -8.92 22 -24 29 -106 #52 #53 #54 #55 #56 #57 #58 #59
c    copper case section
51  9 -8.92 49 -106 104 -22
c    stainless bolt
52  5 -8.0 29 -105 -25
c    stainless bolt
53  5 -8.0 29 -105 -26
c    stainless bolt
54  5 -8.0 29 -105 -27
c    stainless bolt
55  5 -8.0 29 -105 -28
c    stainless bolt tip
56  5 -8.0 105 -109
c    stainless bolt tip
57  5 -8.0 105 -110
c    stainless bolt tip
58  5 -8.0 105 -111
c    stainless bolt tip
59  5 -8.0 105 -112
c    void center of brass mounting for DFT
60  0 -55 52 -56
c    brass annulus mounting for DFT
61  1 -8.53 55 52 -59 -56
c    brass annulus mounting for DFT
62  1 -8.53 56 58 -59 -57
c    void center of brass mounting for DFT
63  0 56 -58 -57
c    void center of brass mounting for DFT
64  0 57 -58 -68
c    rubber mounting spacer for DFT
65  6 -7.4723 57 58 -61 -68
c    PMMA spacer for DFT
66  7 -1.19 57 -59 61 -68
c    DFT, electrically active part
67  8 -2.33 -67 68 -69
c    void
68  0 59 -89 52 -72 #111 #112 #113 #114
c    DFT, electrically inactive part
69  8 -2.33 67 -62 68 -69
c    PMMA spacer for DFT
70  7 -1.19 -59 68 62 -72
c    void space between DFT and brass mounting
71  0 69 -70 61 -62
c    rubber mounting spacer for DFT
72  6 -7.4723 69 -107 58 -61
c    void center below DFT
73  0 69 -71 -58
c    brass annulus mounting for DFT
74  1 -8.53 -107 70 -62 61
c    brass annulus mounting for DFT
75  1 -8.53 107 -71 58 -62
c    brass annulus mounting for DFT
76  1 -8.53 71 73 -72 -62
c    void center below DFT
77  0 -73 71 -72
c    PCB annulus
78  2 -2.7 75 72 -74 -89 #111 #112 #113 #114
c    void
79  0 59 -89 74 -85 #111 #112 #113 #114
c    void at center of PCB annulus
80  0 -75 72 -74
c    void at center of brass mounting for DBT
81  0 74 -77 -113
c    brass annulus mounting for DBT
82  1 -8.53 113 74 -77 -59
c    brass annulus mounting for DBT
83  1 -8.53 77 -78 76 -59
c    void at center of brass mounting for DBT
84  0 77 -79 -76

```

```

c      rubber spacer for DBT
85 6 -7.4723 78 -79 76 -108
c      PMMA spacer for DBT
86 7 -1.19 78 -79 108 -59
c      PMMA spacer for DBT
87 7 -1.19 79 -85 62 -59
c      DBT, electrically active part
88 8 -2.33 79 -81 -80
c      DBT, electrically inactive part
89 8 -2.33 79 -81 80 -62
c      void space between DBT and brass mounting
90 0 -62 81 -82 108
c      rubber spacer for DBT
91 6 -7.4723 81 -83 76 -108
c      void at center of brass mounting for DBT
92 0 81 -84 -76
c      brass annulus mounting for DBT
93 1 -8.53 82 -83 108 -62
c      brass annulus mounting for DBT
94 1 -8.53 83 -84 -62 76
c      brass annulus mounting for DBT
95 1 -8.53 84 -85 -62 86
c      void at center of brass mounting for DBT
96 0 84 -85 -86
c      void at center of PCB annulus
97 0 85 -87 -93
c      void annulus above PCB
98 0 88 85 -91 -89 #111 #112 #113 #114
c      gold spacer annulus on PCB
99 4 -18.88 85 -91 -88 87
c      PCB annulus
100 2 -2.7 -89 87 91 -92 #111 #112 #113 #114
c      void annulus below PCB
101 0 92 -93 -89 88 #111 #112 #113 #114
c      gold spacer annulus below PCB
102 4 -18.88 92 -93 -88 87
c      PMMA base annulus section
103 7 -1.19 59 -89 93 -101 #111 #112 #113 #114
c      PMMA base annulus section
104 7 -1.19 101 59 -89 -102 #115 #116 #117 #118
c      PMMA base annulus section
105 7 -1.19 59 -89 102 -94
c      PMMA base annulus section
106 7 -1.19 -59 93 90 -94
c      void at center of base PMMA annulus
107 0 -90 93 -94
c      void below PMMA annulus
108 0 94 -95 -89
c      copper case bottom
109 9 -8.92 95 -96 -104
c      copper case side/bottom
110 9 -8.92 106 -96 104 -24
c      PMMA rod
111 7 -1.19 103 -101 -63
c      PMMA rod
112 7 -1.19 103 -101 -64
c      PMMA rod
113 7 -1.19 103 -101 -65
c      PMMA rod
114 7 -1.19 103 -101 -66
c      PMMA rod
115 7 -1.19 101 -102 -97
c      PMMA rod
116 7 -1.19 101 -102 -98
c      PMMA rod
117 7 -1.19 101 -102 -99
c      PMMA rod
118 7 -1.19 101 -102 -100
c      outside case
c      aluminum top plate
119 2 -2.7 114 -29 117 -120 121 -124 #125 #139 #140 #141 #142
c      aluminum bottom plate
120 2 -2.7 115 -116 117 -120 121 -124 #139 #140 #141 #142
c      low x-side plate
121 2 -2.7 117 -118 29 -115 121 -124

```

```

c    high x-side plate
122  2 -2.7 119 -120 29 -115 121 -124
c    low y-side plate
123  2 -2.7 121 -122 29 -115 118 -119
c    high y-side plate
124  2 -2.7 123 -124 29 -115 118 -119
c    hole in case top to expose telescope aperture
125  0 114 -29 -1
c    micarta board
126  2 -2.7 96 -125 118 -119 122 -123 #142 #139 #140 #141
c    micarta board
127  2 -2.7 126 -127 118 -119 122 -123 #142 #139 #140 #141
c    micarta board
128  2 -2.7 128 -129 118 -119 122 -123 #142 #139 #140 #141
c    micarta board
129  2 -2.7 130 -131 118 -119 122 -123 #142 #139 #140 #141
c    micarta board
130  2 -2.7 132 -133 118 -119 122 -123 #142 #139 #140 #141
c    micarta board
131  2 -2.7 134 -135 118 -119 122 -123 #142 #139 #140 #141
c    void between top Al plate and top micarta board; excludes corner
c    bolts and telescope
132  0 29 -96 118 -119 122 -123 24 #139 #140 #141 #142
c    void between boards
133  0 125 -126 118 -119 122 -123
    #139 #140 #141 #142 #143 #149 #155 #161
c    void between boards
134  0 127 -128 118 -119 122 -123
    #139 #140 #141 #142 #144 #150 #156 #162
c    void between boards
135  0 129 -130 118 -119 122 -123
    #139 #140 #141 #142 #145 #151 #157 #163
c    void between boards
136  0 131 -132 118 -119 122 -123
    #139 #140 #141 #142
    #146 #152 #158 #164
c    void between boards
137  0 133 -134 118 -119 122 -123
    #139 #140 #141
    #142 #147 #153 #159 #165
c    void between boards
138  0 135 -115 118 -119 122 -123
    #139 #140 #141 #142 #148 #154 #160 #166
c    stainless corner bolt (case)
139  5 -8.0 -136 -116 114
c    stainless corner bolt (case)
140  5 -8.0 -137 -116 114
c    stainless corner bolt (case)
141  5 -8.0 -138 -116 114
c    stainless corner bolt (case)
142  5 -8.0 -139 -116 114
c
c    PMMA spacers(24) wrapped around stainless corner bolts
c    cells 143-166
143  7 -1.19 136 -140 #139 125 -126
144  7 -1.19 136 -140 #139 127 -128
145  7 -1.19 136 -140 #139 129 -130
146  7 -1.19 136 -140 #139 131 -132
147  7 -1.19 136 -140 #139 133 -134
148  7 -1.19 136 -140 #139 135 -115
149  7 -1.19 137 -141 #140 125 -126
150  7 -1.19 137 -141 #140 127 -128
151  7 -1.19 137 -141 #140 129 -130
152  7 -1.19 137 -141 #140 131 -132
153  7 -1.19 137 -141 #140 133 -134
154  7 -1.19 137 -141 #140 135 -115
155  7 -1.19 138 -142 #141 125 -126
156  7 -1.19 138 -142 #141 127 -128
157  7 -1.19 138 -142 #141 129 -130
158  7 -1.19 138 -142 #141 131 -132
159  7 -1.19 138 -142 #141 133 -134
160  7 -1.19 138 -142 #141 135 -115
161  7 -1.19 139 -143 #142 125 -126
162  7 -1.19 139 -143 #142 127 -128
163  7 -1.19 139 -143 #142 129 -130
164  7 -1.19 139 -143 #142 131 -132

```

```

166 7 -1.19 139 -143 #142 135 -115
c
c exterior void region (1 cm thick ) above top z-plate
167 0 144 -114 146 -147 148 -149
c exterior void region (1 cm thick ) below bottom z-plate
168 0 116 -145 146 -147 148 -149
c exterior void region (1 cm thick ) outside lower x-plate
169 0 146 -117 148 -149 114 -116
c exterior void region (1 cm thick ) outside upper x-plate
170 0 120 -147 148 -149 114 -116
c exterior void region (1 cm thick ) outside lower y-plate
171 0 117 -120 148 -121 114 -116
c exterior void region (1 cm thick ) outside upper y-plate
172 0 117 -120 124 -149 114 -116
c escape region (extends to infinity in all directons)
173 0 -144:145:-148:149:-146:147

```

```

c Surfaces
c
1 cz 0.5334
2 cz 0.5080
3 cz 0.4826
4 cz 0.4572
5 cz 0.4318
6 cz 0.4064
7 cz 0.3810
8 cz 0.3556
9 cz 0.3302
10 cz 0.3048
11 cz 0.2794
12 cz 0.2540
13 cz 0.2286
14 cz 0.2032
15 cz 0.1778
16 cz 0.1524
17 cz 0.1270
18 cz 0.1016
19 cz 0.4191
20 cz 0.02286
21 cz 0.750711
22 cz 1.06680
24 cz 1.5240
25 c/z 1.27 0.00 0.143111
26 c/z 0.00 1.27 0.143111
27 c/z -1.27 0.00 0.143111
28 c/z 0.00 -1.27 0.143111
29 pz 0.00000
30 pz 0.02540
31 pz 0.05080
32 pz 0.07620
33 pz 0.1016
34 pz 0.1270
35 pz 0.1524
36 pz 0.1778
37 pz 0.2032
38 pz 0.2286
39 pz 0.2540
40 pz 0.2794
41 pz 0.3048
42 pz 0.3302
43 pz 0.3556
44 pz 0.3810
45 pz 0.4064
46 pz 0.4318
47 pz 0.4572
48 pz 0.4581
49 pz 0.5080
51 pz 0.51652
52 pz 0.56732
53 cz 0.3111
55 kz 0.87842 1.0 -1
56 pz 0.592208
57 pz 0.64199
58 cz 0.28622
59 cz 0.8000

```

60	cz	0.6295			
61	cz	0.34844			
62	cz	0.73422			
63	c/z	0.9087555	0.00	0.0248889	
64	c/z	0.00	0.9087555	0.0248889	
65	c/z	-0.9087555	0.00	0.0248889	
66	c/z	0.00	-0.9087555	0.0248889	
67	cz	0.4021			
68	pz	0.704212			
69	pz	0.719212			
70	pz	0.744212			
71	pz	0.856101			
72	pz	0.918323			
73	kz	0.569883	1.0	+1	
74	pz	0.969123			
75	cz	0.423111			
76	cz	0.373111			
77	pz	1.019123			
78	pz	1.043789			
79	pz	1.113477			
80	cz	0.518942			
81	pz	1.163477			
82	pz	1.203477			
83	pz	1.243477			
84	pz	1.293477			
85	pz	1.352774			
86	kz	0.920366	1.0	+1	
87	cz	0.4064			
88	cz	0.6096			
89	cz	1.001777			
90	cz	0.5080			
91	pz	1.360394			
92	pz	1.41119			
93	pz	1.41881			
94	pz	1.971965			
95	pz	2.046631			
96	pz	2.29552			
97	c/z	0.9087555	0.00	0.0734222	
98	c/z	0.00	0.9087555	0.0734222	
99	c/z	-0.9087555	0.00	0.0734222	
100	c/z	0.00	-0.9087555	0.0734222	
101	pz	1.518365			
102	pz	1.953921			
103	pz	0.448143			
104	cz	1.027288			
105	pz	1.142666			
106	pz	1.29200			
107	pz	0.787657			
108	cz	0.43533			
109	k/z	1.27	0.00	1.292	0.8575536 -1
110	k/z	0.00	1.27	1.292	0.8575536 -1
111	k/z	-1.27	0.00	1.292	0.8575536 -1
112	k/z	0.00	-1.27	1.292	0.8575536 -1
113	kz	1.392234	1.0	-1	
114	pz	-0.2032			
115	pz	7.5565			
116	pz	8.1661			
117	px	-2.54			
118	px	-2.3368			
119	px	7.4168			
120	px	7.62			
121	py	-2.54			
122	py	-2.3368			
123	py	7.4168			
124	py	7.62			
125	pz	2.454275			
126	pz	3.137535			
127	pz	3.296285			
128	pz	3.979545			
129	pz	4.138295			
130	pz	4.821555			
131	pz	4.980305			
132	pz	5.663565			
133	pz	5.822315			
134	pz	6.505575			
135	pz	6.664325			
136	c/z	-1.79605	-1.79605	0.1058333	


```

137 c/z 6.87605 -1.79605 0.1058333
138 c/z 6.87605 6.87605 0.1058333
139 c/z -1.79605 6.87605 0.1058333
140 c/z -1.79605 -1.79605 0.21167
141 c/z 6.87605 -1.79605 0.21167
142 c/z 6.87605 6.87605 0.21167
143 c/z -1.79605 6.87605 0.21167
144 pz -1.2032
145 pz 9.166
146 px -3.54
147 px 8.62
148 py -3.54
149 py 8.62
C
c Transport protons, neutrons, muons, photons, pions

mode h n | p /
c Source definition, proton source (par=9), located on surface
c #114 which is the plane at z=-0.2032, centered at 0.,0.-,0.2032,
c with radius 1.4 cm, energy 300 MeV,Normal incidence (along z)
SDEF sur=114 pos=0. 0. -.2032 rad=D1 ERG=300. WGT=1.0 DIR=1 par=9
SI1 .25
VOL 45J 0.144715 3J 4.501818 27J 0.1311943 21J 0.1333961
2J 0.1129316 0.4679637 14J 19.61581 61.74832 5J
139.2479 139.2432 103.1126 103.1126 103.1126
103.1126 42J
c No. of histories
NPS 1000
C
C Materials
C
C Brass
M1 29000 -.3 28000 -.7
C Aluminum
M2 13027 -1.0
C Tungsten
M3 74000 -.95 29000 -.015 28000 -.035
C Gold
M4 79197 -1.0
C Stainless Steel
M5 26000 -.71 29000 -.17 25055 -.065 28000 -.005 14000 -.05
C Conductive Silicone Elastomer
M6 28000 -.377 47000 -.373 14000 -.0947
6000 -.0810 8016 -.0539 1001 -.0204
C PMMA
M7 6000 -.59985 8016 -.31961 1001 -.080538
C Silicon
M8 14000 -1.0
C Copper
M9 29000 -1.0
c maximum proton energy(MeV) required for cross section table
PHYS:h 400.
c maximum neutron energy(MeV) required for cross section table
PHYS:n 400.
c maximum muon energy(MeV) required for cross section table
PHYS:| 400.
c maximum photon energy(MeV) required for cross section table
PHYS:p 400.
c maximum pion energy(MeV) required for cross section table
PHYS:/ 400.
c Tallies
c F46:p, F56:p, F66:p, F76:p, F86:p are photon track length
c energy deposition (heating) tallies (MeV/gm)
F46:p 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
F56:p 36 37 38 39 40 43 46 48 50 51 52 53 54 55 56 57 58
F66:p 59 61 62 65 66 67 70 72 74 75 76 78 82 83 85 86 87
F76:p 88 89 91 93 94 95 99 100 102 103 104 105 106 109

```

```

F86:p  110 111 112 113 114 115 116 117 118 119 120 121 122 123 124
      126 127 128 129 139 131 139 140 141 142 143 144 145 146 147
      148 149 150 151 152 153 154 155 156 157 158 159 160 161
      162 163 164 165 166
c + F6:n,p,h, etc are proton energy deposition tallies
+F6:n,p  19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
+F16:n,p  36 37 38 39 40 43 46 48 50 51 52 53 54 55 56 57 58
+F26:n,p  59 61 62 65 66 67 70 72 74 75 76 78 82 83 85 86 87
+F36:n,p  88 89 91 93 94 95 99 100 102 103 104 105 106 109
+F106:n,p 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124
      126 127 128 129 130 131
      139 140 141 142 143 144 145 146 147 148 149
      150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165
      166
c      charge deposition tallies
+F98:h  19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
+F58:h  36 37 38 39 40 43 46 48 50 51 52 53 54 55 56 57 58
+F68:h  59 61 62 65 66 67 70 72 74 75 76 78 82 83 85 86 87
+F78:h  88 89 91 93 94 95 99 100 102 103 104 105 106 109
+F88:h  110 111 112 113 114 115 116 117 118 119 120 121 122 123 124
      126 127 128 129 130 131
      139 140 141 142 143 144 145 146 147
      148 149 150 151 152 153 154 155 156 157 158 159 160 161 162
      163 164 165 166
c      proton flux tallies
F44:h  19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
F54:h  36 37 38 39 40 43 46 48 50 51 52 53 54 55 56 57 58
F64:h  59 61 62 65 66 67 70 72 74 75 76 78 82 83 85 86 87
F74:h  88 89 91 93 94 95 99 100 102 103 104 105 106 109
F84:h  110 111 112 113 114 115 116 117 118 119 120 121 122 123 124
      126 127 128 129 130 131
      139 140 141 142 143 144 145 146 147 148 149
      150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165
      166
c      neutron flux tallies
F144:n  19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
F154:n  36 37 38 39 40 43 46 48 51 50 52 53 54 55 56 57 58
F164:n  59 61 62 65 66 67 70 72 74 75 76 78 82 83 85 86 87
F174:n  88 89 91 93 94 95 99 100 102 103 104 105 106 109
F184:n  110 111 112 113 114 115 116 117 118 119 120 121 122 123 124
      126 127 128 129 130 131
      139 140 141 142 143 144 145 146 147 148 149
      150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165
      166
c      proton energy flux tallies
*F104:h  19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35
*F114:h  36 37 38 39 40 43 46 48 51 50 52 53 54 55 56 57 58
*F124:h  59 61 62 65 66 67 70 72 74 75 76 78 82 83 85 86 87
*F134:h  88 89 91 93 94 95 99 100 102 103 104 105 106 109
*F94:h  110 111 112 113 114 115 116 117 118 119 120 121 122 123 124
      126 127 128 129 130 131
      139 140 141 142 143 144 145 146 147 148 149
      150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165
      166
c      cell importances for protons
imp:h  1 165R  0 6R
c      cell importances for photons
imp:p  1 165R  0 6R
c      cell importances for neutrons
imp:n  1 165R  0 6R
c      cell importances for muons
imp:|  1 165R  0 6R
c      cell importances for pions
imp:/  1 165R  0 6R
ptrac write=all file=asc

```

APPENDIX 4
MCNPX Input File
For
150 MeV Proton Source Entering HEP through Side of Aluminum Case
(see Figure 9(b), surface #145).
3.0 cm Radius Disk Source; Isotropic Incidence.

```

Test for protons  HEP in- flight version for MCNPX
C
C  Proton, neutron, muon, pion, photon
C  transport - 150 MeV protons isotropic angular dist on x face of box
C
C    Cells
C
c    collimator
1    0  1 -3 -7
c    Tungsten P17
2    3 -18.0 1 -3 -5 #1
c    Tungsten P17
3    3 -18.0 1 -2 5 -4
c    Copper P16
4    9 -8.92 2 -8 5 -6
c    Copper P16
5    9 -8.92 8 -3 5 -4
c    Copper P16
6    9 -8.92 3 -9 -4
c    Plastic Kel-F P4
7    13 -2.2 9 -10 -4
c    Phosphor Bronze P9
8    1 -8.89 10 -13 14 -12
c    void P9
9    0 10 -13 -14
c    Plastic Kel-F P4
10   13 -2.2 10 -11 -4 12
c    Plastic Kel-F P8
11   13 -2.2 13 -15 -12 18
c    Plastic Kel-F P4
12   13 -2.2 11 12 -16 -4
c    Phosphor Bronze P9
13   1 -8.89 15 -16 14 -12
c    void P9
14   0 15 -16 -14
c    Plastic Kel-F P4
15   13 -2.2 16 -17 -4
c
c    D1 assembly starts here
c    PCB Ring mount
16   2 -2.7 13 -20 -18 24
c    PCB Ring mount
17   2 -2.7 20 -19 -21 24
c    PCB Ring mount
18   2 -2.7 21 -23 -19 24
c    PCB Ring mount
19   2 -2.7 23 24 -18 -15
20   0 13 -21 -30
21   0 21 -22 -29
c    PCB Ring mount
22   2 -2.7 13 -21 -24 #20
23   0 21 -22 -24 28
c    Rubber wafer mount
24   6 -7.47 29 -28 -22 21
c    Oxide ring
25   11 -2.32 29 -25 22 -23
c    Aluminum coating on Si wafer
26   2 -2.7 22 -23 -29
c    Silicon wafer
27   8 -2.33 23 -26 -25
c    Aluminum coating on Si wafer

```

```

28 2 -2.7 26 -27 -25
29 0 22 -15 -24 #25 #26 #27 #28
30 0 19 20 -18 -23
c
c end of D1 assembly
c
c Plastic Kel-F P4
31 13 -2.2 17 -31 -4
c Phosphor Bronze P9
32 1 -8.89 31 -32 -12 14
33 0 31 -32 -14
c Plastic Kel-F P4
34 13 -2.2 31 -33 12 -4
c Plastic Kel-F P5
35 13 -2.2 33 12 -4 -35
c Plastic Kel-F P8
36 13 -2.2 32 -12 18 -34
c Phosphor Bronze P9
37 1 -8.89 34 -35 -12 14
38 0 34 -35 -14
c Plastic Kel-F P5
39 13 -2.2 35 -36 -4
c
c D2 assembly starts here
c
c PCB Ring mount
40 2 -2.7 32 -37 -18 24
c PCB Ring mount
41 2 -2.7 37 -19 -39 24
c PCB Ring mount
42 2 -2.7 39 -38 -19 24
c PCB Ring mount
43 2 -2.7 38 24 -18 -34
44 0 32 -39 -41
45 0 39 -40 -29
c PCB Ring mount
46 2 -2.7 32 -39 -24 #44
47 0 39 -40 -24 28
c Rubber wafer mount
48 6 -7.47 29 -28 -40 39
c Oxide ring
49 11 -2.32 29 -25 40 -38
c Aluminum coating on Si wafer
50 2 -2.7 40 -38 -29
c Silicon wafer
51 8 -2.33 38 -42 -25
c Aluminum coating on Si wafer
52 2 -2.7 42 -43 -25
53 0 40 -34 -24 #49 #50 #51 #52
54 0 19 -18 37 -38
c
c end of D2 assembly
c
c start of S1, S3 assembly
c
c Plastic Kel-F P5
55 13 -2.2 36 -44 -45 46
c Plastic Kel-F P5
56 13 -2.2 36 -44 -47
c Spectralon P13, P14 with rectangular cut (cell 122)
57 12 -2.2 36 -49 45 -4 #122 #123
c Spectralon P10, P11 with rectangular cut (cell 121)
58 12 -2.2 36 -49 47 -46 #121 #119
c Scintillator - S3 with rectangular cut and pin diode (cells 123, 124)
59 4 -1.03 44 -48 46 -45 #123 #124
c GSO S1 with pin diode on flat (cells 119, 120)
60 10 -7.05 44 -48 -47 #119 #120
c Plastic Kel-F P5
61 13 -2.2 48 -49 46 -45
c Plastic Kel-F P5
62 13 -2.2 48 -49 -47
c Plastic Kel-F P5
63 13 -2.2 49 -50 -4
c end of S3, S1 assembly
c

```

```

c      Phosphor Bronze P9B
64 1 -8.89 50 -51 -12
c      Plastic Kel-F P5
65 13 -2.2 50 -52 12 -4
c      Plastic Kel-F P6
66 13 -2.2 52 -54 12 -4
c      Phosphor Bronze P9B
67 1 -8.89 53 -54 -12
c      Plastic Kel-F P6
68 13 -2.2 54 -55 -4
c      Plastic Kel-F P6
69 13 -2.2 55 -56 -57
c      Plastic Kel-F P7
70 13 -2.2 51 -53 58 -12
c
c      start D3 assembly
c      void
71 0 51 -59 -66
c      void
72 0 59 -60 -68
c      PCB annulus
73 2 -2.7 51 -60 -58 #71 #72
c      PMMA
74 7 -1.19 60 -61 70 -58
c      PMMA
75 7 -1.19 57 -58 61 -53
c      void
76 0 60 -61 -69
c      Si wafer - electrically active part
77 8 -2.33 61 -62 -70
c      Si wafer - electrically inactive part
78 8 -2.33 70 -57 61 -62
c      void
79 0 62 -63 70 -57
c      rubber mounting spacer
80 6 -7.47 69 -70 60 -61
c      rubber mounting spacer
81 6 -7.47 69 -70 62 -64
c      PCB annulus
82 2 -2.7 63 -64 70 -57
c      PCB annulus
83 2 -2.7 64 -53 -57 #85 #86
c      void
84 0 62 -64 -69
c      void
85 0 64 -65 -68
c      void
86 0 65 -53 -67
c      end D3 assembly
c
c      begin S2 assembly
c      GSO S2
87 10 -7.05 56 -57 -71 #125 #126 #127
c      Spectralon P12
88 12 -2.2 55 -72 57 -4 #128 #129 #130 #131
c      Plastic Kel-F P6
89 13 -2.2 71 -72 -57
c      Plastic Kel-F P6
90 13 -2.2 72 -73 -4
c      Plastic Kel-F P6
91 13 -2.2 73 -75 12 -4
c      phosphor bronze P9B
92 1 -8.89 73 -74 -12
c      Plastic Kel-F P4
93 13 -2.2 12 -4 75 -77
c      phosphor bronze P9B
94 1 -8.89 76 -77 -12
c      Plastic Kel-F P4
95 13 -2.2 77 -78 -4
c      end S2 assembly
c
c      begin D4 assembly
c      void
96 0 74 -79 -86
c      void
97 0 79 -80 -88

```

```

c    PCB annulus
98  2 -2.7      88 74 -80 -12 #96 #97
c    PMMA
99  7 -1.19     80 -81 90 -12
c    PMMA
100 7 -1.19     91 -12 81 -76
c    void
101 0 80 -81 -89
c    Si wafer - electrically active epart
102 8 -2.33     81 -82 -90
c    Si wafer - electrically inactive part
103 8 -2.33     81 -82 90 -91
c    void
104 0 82 -83 90 -91
c    rubber mounting spacer
105 6 -7.47     80 -81 89 -90
c    rubber mounting spacer
106 6 -7.47     82 -84 89 -90
c    PCB annulus
107 2 -2.7      90 -91 83 -84
c    PCB annulus
108 2 -2.7      84 -91 -76 #110 #111
c    void
109 0 82 -84 -89
c    void
110 0 84 -85 -88
c    void
111 0 85 -76 -87
c    end of D4 assembly
c
c    Aluminum P18
112 2 -2.7      78 -92 -4 98
c    Aluminum P18
113 2 -2.7      92 -94 93 -4
c    Copper base P15
114 9 -8.92     92 -94 -93
c    Copper base P15
115 9 -8.92     94 -95 -6
c    Copper case cylinder
116 9 -8.92     8 4 -94 -6 #132 #133
c    Stainless bulkhead
117 5 -8.0      95 -96 -97 #149
c    void
118 0 78 -92 -98
c
c    pin diode mounted on S1 flat
119 8 -2.33 99 -100 103 -104 113 -114
c    flat slot on S1 for diode
120 0 99 -47 44 -105 #119
c    rectangular cut in P10,P11 assembly
c    plane 99 is used as the ambiguity surface
121 0 47 -46 36 -105 113 -114 99 #119
c    rectangular cut in P13,P14 assembly
c    plane 108 is used as the ambiguity surface
122 0 45 -4 106 -107 101 -102 108 #123
c
c    pin diode mounted on S3 flat
123 8 -2.33 108 -109 110 -111 101 -102
c    flat slot on S3 for diode
124 0 108 -45 106 -107 #123
c
c    PIN diode mounted on S2 flat (portion carved out of S2)
125 8 -2.33 115 -57 118 -119
c    void cells carved out of S2
126 0 56 115 -118 -57
127 0 119 115 -117 -57
c    void cells carved out of P12 bushing
128 0 56 -118 57 -116 99
129 0 119 -117 57 -116 99
130 8 -2.33 118 -119 115 -116 101 -102 #125
c    rectangular cut in P12
131 0 56 -117 116 -4 101 -102 99
c
c    flat on copper case to accommodate copper pin shield
132 0 120 -94 121 -6 #134
c    slot in copper case (99 is ambiguity surface)

```

```

133 0 4 -121 8 -92 99 122 -123
c copper pin shield
134 9 -8.92 121 -124 125 -126 120 -127 #135 #136 #137 #138 #139 #140
      #141 #142 #143 #144 #145 #146 #147 #148
c pin holes in copper pin shield
135 0 121 -124 -128
136 0 121 -124 -129
137 0 121 -124 -130
138 0 121 -124 -131
139 0 121 -124 -132
140 0 121 -124 -133
141 0 121 -124 -134
142 0 121 -124 -135
143 0 121 -124 -136
144 0 121 -124 -137
145 0 121 -124 -138
146 0 121 -124 -139
147 0 121 -124 -140
148 0 121 -124 -141
c
c flat bite out of the stainless bulkhead
149 0 -142 95 -96 -97
c
c Aluminum box
c back plate perp. to z (0.1" thick)
150 2 -2.7 143 -95 144 -148 146 -147 #115
c front plate perp. to z (0.1" thick)
151 2 -2.7 1 -2 144 -148 146 -147 #1 #2 #3
c top plate perp. to x (0.1" thick)
152 2 -2.7 1 -95 148 -145 146 -147
c bottom plate perp. to x (0.25" thick)
153 2 -2.7 1 -95 144 -149 146 -147
c upper side plate perp. to y (0.1" thick) sits on bottom x-plate
c and butts inside top x-plate, and butts inside both z-plates
154 2 -2.7 2 -143 149 -148 150 -147 #156
c lower side plate perp. to y (0.1" thick) sits on bottom x-plate
c and butts inside top x-plate, and butts inside both z-plates
155 2 -2.7 2 -143 149 -148 -151 146 #157
c large connector hole (rectangular) in upper y plate
156 0 150 -147 152 -153 154 -155
c small connector hole (rectangular) in lower y plate
157 0 146 -151 156 -157 158 -159
c exterior void outside lower z plate (1 cm thick)
158 0 -1 160 144 -145 146 -147
c exterior void outside upper z plate (1 cm thick)
159 0 95 -96 97 -145 146 -147 99
160 0 96 -161 144 -145 146 -147
c exterior void outside lower x plate (1 cm thick)
161 0 162 -144 160 -95 146 -147 -99
162 0 97 95 -96 162 146 -147 -99
163 0 -144 96 162 -161 146 -147
c exterior void outside upper x plate (1 cm thick)
164 0 -163 145 160 -161 146 -147
c exterior void outside lower y plate (1 cm thick)
165 0 164 -146 160 -161 162 -163
c exterior void outside upper y plate (1 cm thick)
166 0 147 -165 160 -161 162 -163
c void region inside box, excluding hep instrument
167 0 2 -143 149 -148 151 -150 6
c exterior void escape region
168 0 -160:161:-162:163:-164:165

c Surfaces
c
1 pz 0.0
2 pz 0.254
3 pz 1.4351
4 cz 1.58877
5 cz 0.8001
6 cz 2.0955
7 kz 3.2802 0.034537 -1
8 pz 0.508
9 pz 1.552
10 pz 1.6027
11 pz 1.7932
12 cz 1.4351

```


13	pz	1.61544	
14	cz	0.47625	
15	pz	1.98374	
16	pz	1.99644	
17	pz	2.03454	
18	cz	0.6985	
19	cz	0.635	
20	pz	1.69672	
21	pz	1.76340	
22	pz	1.78940	
23	pz	1.79741	
24	cz	0.5	
25	cz	0.482	
26	pz	1.8314	
27	pz	1.8394	
28	cz	0.3	
29	cz	0.28209	
30	kz	1.95495	2.168864 -1
31	pz	2.08534	
32	pz	2.09804	
33	pz	2.27584	
34	pz	2.46634	
35	pz	2.47904	
36	pz	2.5298	
37	pz	2.1793	
38	pz	2.28	
39	pz	2.2460	
40	pz	2.2720	
41	kz	2.4375	2.168864 -1
42	pz	2.3140	
43	pz	2.32202	
44	pz	2.58064	
45	cz	1.45415	
46	cz	0.94615	
47	cz	0.75057	
48	pz	5.58038	
49	pz	5.63118	
50	pz	5.68198	
51	pz	5.69468	
52	pz	5.89788	
53	pz	6.10108	
54	pz	6.11378	
55	pz	6.16466	
56	pz	6.21538	
57	cz	1.0	
58	cz	1.105	
59	pz	5.7221	
60	pz	5.7495	
61	pz	5.83133	
62	pz	5.90194	
63	pz	5.9195	
64	pz	5.97256	
65	pz	6.01243	
66	kz	6.43183	0.945216 -1
67	kz	4.86572	0.3620646 +1
68	cz	0.69	
69	cz	0.74334	
70	cz	0.82335	
71	pz	8.21436	
72	pz	8.26516	
73	pz	8.31596	
74	pz	8.32866	
75	pz	8.53186	
76	pz	8.73506	
77	pz	8.74776	
78	pz	8.79856	
79	pz	8.35609	
80	pz	8.38352	
81	pz	8.46531	
82	pz	8.53592	
83	pz	8.55345	
84	pz	8.60654	
85	pz	8.64641	
86	kz	9.35914	.944856 -1
87	kz	7.02605	.362067 +1
88	cz	0.975	

```

89      cz  1.02834
90      cz  1.10835
91      cz  1.32319
92      pz  8.86460
93      cz  1.27
94      pz  9.1694
95      pz  10.16
96      pz  10.47750
97      cz  2.921
98      cz  0.9525
99      px  0.4788
100     px  0.6574
101     py -0.635
102     py  0.635
103     pz  2.61874
104     pz  4.0665
105     pz  4.10464
106     pz  3.342464
107     pz  4.86664
108     px  1.18237
109     px  1.36097
110     pz  3.380564
111     pz  4.82854
c       surface 112 no longer used
c       112      pz -0.1
113     py -0.5780189
114     py  0.5780189
115     px  .94615
116     px  1.12475
117     pz  7.73938
118     pz  6.25348
119     pz  7.70128
120     pz  1.1684
121     px  1.8415
122     py  -.1143
123     py  .1143
124     px  2.0955
125     py -0.9525
126     py  0.9525
127     pz  9.1059
128     c/x  0.  1.6764  0.08
129     c/x  0.  1.9304  0.08
130     c/x  0.  2.21488  0.08
131     c/x  0.  2.46888  0.08
132     c/x  0.  3.01752  0.08
133     c/x  0.  3.27152  0.08
134     c/x  0.  4.21386  0.08
135     c/x  0.  4.46786  0.08
136     c/x  0.  5.88010  0.08
137     c/x  0.  6.13410  0.08
138     c/x  0.  7.01294  0.08
139     c/x  0.  7.26694  0.08
140     c/x  0.  8.54456  0.08
141     c/x  0.  8.79956  0.08
142     px  -2.667
143     pz  9.906
144     px  -2.794
145     px  4.318
146     py -3.9624
147     py  3.9624
148     px  4.064
149     px  -2.159
150     py  3.7084
151     py -3.7084
152     pz  1.508125
153     pz  8.611575
154     px  -1.524
155     px  -.016
156     px  -1.5748
157     px  -.9398
158     pz  3.889375
159     pz  6.270625
160     pz  -1.0
161     pz  11.16
162     px  -3.794
163     px  5.318

```

```

164 py -4.9624
165 py 4.9624
C
c Transport protons

mode h
c Source definition, proton source (par=9), located on surface
c #145 which is the plane at X=4.318,
c with radius 3.0 cm, energy 150 MeV, ISOTROPIC incidence
SDEF sur=145 pos=4.318 0. 5.08 NRM=-1 rad=D1 ERG=150. WGT=1.0 par=9
SI1 3.0
VOL 56J 3.805344 3.060979 10.92574 4.976314 21J 0.01776879
    4J 6.244362 9.046072 27J 40.73179 8.381271
    7J 0.03383785 4J 0.2945550 3J 3.769220
    15J 10.81179 9.926189 17J
c No. of histories
NPS 1000
C
C Materials
C
C Phosphor Bronze
M1 29000 -.9865 50000 -0.0125 15031 -0.001
C Aluminum
M2 13027 -1.0
C Tungsten
M3 74000 -.95 29000 -.015 28000 -.035
C Plastic Scintillator
M4 6000 -0.9205 1001 -0.0795
C Stainless Steel
M5 26000 -.71 29000 -.17 25055 -.065 28000 -.005 14000 -.05
C Conductive Silicone Elastomer
M6 28000 -.377 47000 -.373 14000 -.0947
    6000 -.0810 8016 -.0539 1001 -.0204
C PMMA
M7 6000 -.59985 8016 -.31961 1001 -.080538
C Silicon
M8 14000 -1.0
C Copper
M9 29000 -1.0
C
C GSO
M10 64000 -0.74259 14000 -0.066889 8016 -0.190521
C
C Silicon Dioxide
M11 14000 -0.467435 8016 -0.532565
C
C Spectralon (Teflon C2F4)
M12 6000 -0.240183 9019 -0.759817
C
C Kel-F (chlorotrifluoroethylene C2ClF3)
M13 6000 -0.20625 17000 -0.30440 9019 -0.48935
c
c
c maximum proton energy(MeV) required for cross section table
PHYS:h 300.
c
c Tallies
Fl:h 2 3 4
c cell importances for protons
imp:h 1 166R 0

```

APPENDIX 5

ITS-ACCEPT Input File for CEASE Telescope with Frame and Case
(source is a normally incident beam of 9.9 MeV electrons, uniformly distributed over a disk of radius 1.4 cm, positioned directly above the telescope behind the front face of the case – body, cell labels, excepting frame and case, correspond to those shown in Figures 12, 13, resp.)

```

TITLE
  9.9 MEV CEASE TEST PROBLEM FRONT ENTRY, NORMAL INCIDENCE
***** GEOMETRY *****
GEOMETRY 1
*1
  RCC  0.0  0.0  0.0      0.0  0.00000  0.02540  0.5334
*2
  RCC  0.0  0.0  0.02540  0.0  0.00000  0.02540  0.5080
*3
  RCC  0.0  0.0  0.05080  0.0  0.00000  0.02540  0.4826
*4
  RCC  0.0  0.0  0.07620  0.0  0.00000  0.02540  0.4572
*5
  RCC  0.0  0.0  0.10160  0.0  0.00000  0.02540  0.4318
*6
  RCC  0.0  0.0  0.12700  0.0  0.00000  0.02540  0.4064
*7
  RCC  0.0  0.0  0.15240  0.0  0.00000  0.02540  0.3810
*8
  RCC  0.0  0.0  0.17780  0.0  0.00000  0.02540  0.3556
*9
  RCC  0.0  0.0  0.20320  0.0  0.00000  0.02540  0.3302
*10
  RCC  0.0  0.0  0.22860  0.0  0.00000  0.02540  0.3048
*11
  RCC  0.0  0.0  0.25400  0.0  0.00000  0.02540  0.2794
*12
  RCC  0.0  0.0  0.27940  0.0  0.00000  0.02540  0.2540
*13
  RCC  0.0  0.0  0.30480  0.0  0.00000  0.02540  0.2286
*14
  RCC  0.0  0.0  0.33020  0.0  0.00000  0.02540  0.2032
*15
  RCC  0.0  0.0  0.35560  0.0  0.00000  0.02540  0.1778
*16
  RCC  0.0  0.0  0.38100  0.0  0.00000  0.02540  0.1524
*17
  RCC  0.0  0.0  0.40640  0.0  0.00000  0.02540  0.1270
*18
  RCC  0.0  0.0  0.43180  0.0  0.00000  0.02540  0.1016
*19
  RCC  0.0  0.0  0.0      0.0  0.0      0.02540  0.750711
*20
  RCC  0.0  0.0  0.02540  0.0  0.0      0.02540  0.750711
*21
  RCC  0.0  0.0  0.05080  0.0  0.00000  0.02540  0.750711
*22
  RCC  0.0  0.0  0.07620  0.0  0.00000  0.02540  0.750711
*23
  RCC  0.0  0.0  0.10160  0.0  0.00000  0.02540  0.750711
*24
  RCC  0.0  0.0  0.12700  0.0  0.00000  0.02540  0.750711
*25
  RCC  0.0  0.0  0.15240  0.0  0.00000  0.02540  0.750711
*26
  RCC  0.0  0.0  0.17780  0.0  0.00000  0.02540  0.750711
*27
  RCC  0.0  0.0  0.20320  0.0  0.00000  0.02540  0.750711
*28
  RCC  0.0  0.0  0.22860  0.0  0.00000  0.02540  0.750711
*29
  RCC  0.0  0.0  0.25400  0.0  0.00000  0.02540  0.750711
*30
  RCC  0.0  0.0  0.27940  0.0  0.00000  0.02540  0.750711
*31
  RCC  0.0  0.0  0.30480  0.0  0.00000  0.02540  0.750711
*32

```

RCC	0.0	0.0	0.33020	0.0	0.00000	0.02540	0.750711
*33							
RCC	0.0	0.0	0.35560	0.0	0.00000	0.02540	0.750711
*34							
RCC	0.0	0.0	0.38100	0.0	0.00000	0.02540	0.750711
*35							
RCC	0.0	0.0	0.40640	0.0	0.00000	0.02540	0.750711
*36							
RCC	0.0	0.0	0.43180	0.0	0.00000	0.02540	0.750711
*37							
RCC	0.0	0.0	0.45720	0.0	0.00000	0.00090	0.750711
*38							
RCC	0.0	0.0	0.45810	0.0	0.00000	0.04990	0.750711
*39							
RCC	0.0	0.0	0.45720	0.0	0.00000	0.00090	0.4191
*40							
RCC	0.0	0.0	0.45810	0.0	0.00000	0.04990	0.4191
*41							
RCC	0.0	0.0	0.45810	0.0	0.00000	0.04990	0.02286
*42							
RCC	0.0	0.0	0.0	0.0	0.00000	0.3556	1.06680
*43							
RCC	0.0	0.0	0.3556	0.0	0.0	0.1524	1.06680
*44							
RCC	0.9087555	0.0	0.448143	0.0	0.0	0.059857	0.0248889
*45							
RCC	0.0	0.9087555	0.448143	0.0	0.0	0.059857	0.0248889
*46							
RCC	-0.9087555	0.0	0.448143	0.0	0.0	0.059857	0.0248889
*47							
RCC	0.0	-0.9087555	0.448143	0.0	0.0	0.059857	0.0248889
*48							
RCC	1.27	0.0	0.0	0.0	0.0	1.142666	0.143111
*49							
RCC	0.0	1.27	0.0	0.0	0.0	1.142666	0.143111
*50							
RCC	-1.27	0.0	0.0	0.0	0.0	1.142666	0.143111
*51							
RCC	0.0	-1.27	0.0	0.0	0.0	1.142666	0.143111
*52							
TRC	1.27	0.0	1.142666	0.0	0.0	0.149334	0.143111
*53							
TRC	0.0	1.27	1.142666	0.0	0.0	0.149334	0.143111
*54							
TRC	-1.27	0.0	1.142666	0.0	0.0	0.149334	0.143111
*55							
TRC	0.0	-1.27	1.142666	0.0	0.0	0.149334	0.143111
*56							
RCC	0.0	0.0	0.5080	0.0	0.0	0.00852	0.3111
*57							
RCC	0.0	0.0	0.5080	0.0	0.0	0.00852	0.4191
*58							
RCC	0.0	0.0	0.5080	0.0	0.0	0.00852	1.027288
*59							
RCC	0.9087555	0.0	0.5080	0.0	0.0	0.00852	0.0248889
*60							
RCC	0.0	0.9087555	0.5080	0.0	0.0	0.00852	0.0248889
*61							
RCC	-0.9087555	0.0	0.5080	0.0	0.0	0.00852	0.0248889
*62							
RCC	0.0	-0.9087555	0.5080	0.0	0.0	0.00852	0.0248889
*63							
RCC	0.0	0.0	0.51652	0.0	0.0	0.05080	0.3111
*64							
RCC	0.9087555	0.0	0.51652	0.0	0.0	0.05080	0.0248889
*65							
RCC	0.0	0.9087555	0.51652	0.0	0.0	0.05080	0.0248889
*66							
RCC	-0.9087555	0.0	0.51652	0.0	0.0	0.05080	0.0248889
*67							
RCC	0.0	-0.9087555	0.51652	0.0	0.0	0.05080	0.0248889
*68							
RCC	0.0	0.0	0.51652	0.0	0.0	0.05080	1.0017
*69							
RCC	0.0	0.0	0.51652	0.0	0.0	0.05080	1.027288
*70							
TRC	0.0	0.0	0.56732	0.0	0.0	0.024888	0.3111
*71							
RCC	0.0	0.0	0.56732	0.0	0.0	0.024888	0.8
*72							

RCC	0.0	0.0	0.56732	0.0	0.0	0.024888	1.027288	
*73	RCC	0.9087555	0.0	0.56732	0.0	0.0	0.024888	0.0248889
*74	RCC	0.0	0.9087555	0.56732	0.0	0.0	0.024888	0.0248889
*75	RCC	-0.9087555	0.0	0.56732	0.0	0.0	0.024888	0.0248889
*76	RCC	0.0	-0.9087555	0.56732	0.0	0.0	0.024888	0.0248889
*77	RCC	0.0	0.0	0.592208	0.0	0.0	0.049782	0.28622
*78	RCC	0.0	0.0	0.592208	0.0	0.0	0.049782	0.8
*79	RCC	0.0	0.0	0.592208	0.0	0.0	0.049782	1.027288
*80	RCC	0.9087555	0.0	0.592208	0.0	0.0	0.049782	0.0248889
*81	RCC	0.0	0.9087555	0.592208	0.0	0.0	0.049782	0.0248889
*82	RCC	-0.9087555	0.0	0.592208	0.0	0.0	0.049782	0.0248889
*83	RCC	0.0	-0.9087555	0.592208	0.0	0.0	0.049782	0.0248889
*84	RCC	0.0	0.0	0.64199	0.0	0.0	0.062222	0.28622
*85	RCC	0.0	0.0	0.64199	0.0	0.0	0.062222	0.34844
*86	RCC	0.0	0.0	0.64199	0.0	0.0	0.062222	0.8
*87	RCC	0.0	0.0	0.64199	0.0	0.0	0.062222	1.027288
*88	RCC	0.9087555	0.0	0.64199	0.0	0.0	0.062222	0.0248889
*89	RCC	0.0	0.9087555	0.64199	0.0	0.0	0.062222	0.0248889
*90	RCC	-0.9087555	0.0	0.64199	0.0	0.0	0.062222	0.0248889
*91	RCC	0.0	-0.9087555	0.64199	0.0	0.0	0.062222	0.0248889
*92	RCC	0.0	0.0	0.704212	0.0	0.0	0.015	0.4021
*93	RCC	0.0	0.0	0.704212	0.0	0.0	0.015	0.73422
*94	RCC	0.0	0.0	0.704212	0.0	0.0	0.015	0.8
*95	RCC	0.0	0.0	0.704212	0.0	0.0	0.015	1.027288
*96	RCC	0.9087555	0.0	0.704212	0.0	0.0	0.015	0.0248889
*97	RCC	0.0	0.9087555	0.704212	0.0	0.0	0.015	0.0248889
*98	RCC	-0.9087555	0.0	0.704212	0.0	0.0	0.015	0.0248889
*99	RCC	0.0	-0.9087555	0.704212	0.0	0.0	0.015	0.0248889
*100	RCC	0.0	0.0	0.719212	0.0	0.0	0.025	0.28622
*101	RCC	0.0	0.0	0.719212	0.0	0.0	0.025	0.34844
*102	RCC	0.0	0.0	0.719212	0.0	0.0	0.025	0.73422
*103	RCC	0.0	0.0	0.719212	0.0	0.0	0.199111	0.8
*104	RCC	0.0	0.0	0.719212	0.0	0.0	0.199111	1.027288
*105	RCC	0.9087555	0.0	0.719212	0.0	0.0	0.199111	0.0248889
*106	RCC	0.0	0.9087555	0.719212	0.0	0.0	0.199111	0.0248889
*107	RCC	-0.9087555	0.0	0.719212	0.0	0.0	0.199111	0.0248889
*108	RCC	0.0	-0.9087555	0.719212	0.0	0.0	0.199111	0.0248889
*109	RCC	0.0	0.0	0.744212	0.0	0.0	0.043445	0.28622
*110	RCC	0.0	0.0	0.744212	0.0	0.0	0.043445	0.34844
*111	RCC	0.0	0.0	0.744212	0.0	0.0	0.043445	0.73422
*112								

RCC	0.0	0.0	0.787657	0.0	0.0	0.068444	0.28622	
*113								
RCC	0.0	0.0	0.787657	0.0	0.0	0.068444	0.73422	
*114								
TRC	0.0	0.0	0.856101	0.0	0.0	0.062222	0.28622	0.34844
*115								
RCC	0.0	0.0	0.856101	0.0	0.0	0.062222	0.73422	
*116								
RCC	0.0	0.0	0.918323	0.0	0.0	0.05080	0.423111	
*117								
RCC	0.0	0.0	0.918323	0.0	0.0	0.05080	1.001777	
*118								
RCC	0.0	0.0	0.918323	0.0	0.0	0.05080	1.027288	
*119								
RCC	0.9087555	0.0	0.918323	0.0	0.0	0.05080	0.0248889	
*120								
RCC	0.0	0.9087555	0.918323	0.0	0.0	0.05080	0.0248889	
*121								
RCC	-0.9087555	0.0	0.918323	0.0	0.0	0.05080	0.0248889	
*122								
RCC	0.0	-0.9087555	0.918323	0.0	0.0	0.05080	0.0248889	
*123								
TRC	0.0	0.0	0.969123	0.0	0.0	0.0500	0.423111	0.373111
*124								
RCC	0.0	0.0	0.969123	0.0	0.0	0.0500	0.8	
*125								
RCC	0.0	0.0	0.969123	0.0	0.0	0.0500	1.027288	
*126								
RCC	0.9087555	0.0	0.969123	0.0	0.0	0.05	0.0248889	
*127								
RCC	0.0	0.9087555	0.969123	0.0	0.0	0.05	0.0248889	
*128								
RCC	-0.9087555	0.0	0.969123	0.0	0.0	0.05	0.0248889	
*129								
RCC	0.0	-0.9087555	0.969123	0.0	0.0	0.05	0.0248889	
*130								
RCC	0.0	0.0	1.019123	0.0	0.0	0.024666	0.373111	
*131								
RCC	0.0	0.0	1.019123	0.0	0.0	0.024666	0.8	
*132								
RCC	0.0	0.0	1.019123	0.0	0.0	0.024666	1.027288	
*133								
RCC	0.9087555	0.0	1.019123	0.0	0.0	0.024666	0.0248889	
*134								
RCC	0.0	0.9087555	1.019123	0.0	0.0	0.024666	0.0248889	
*135								
RCC	-0.9087555	0.0	1.019123	0.0	0.0	0.024666	0.0248889	
*136								
RCC	0.0	-0.9087555	1.019123	0.0	0.0	0.024666	0.0248889	
*137								
RCC	0.0	0.0	1.043789	0.0	0.0	0.069688	0.373111	
*138								
RCC	0.0	0.0	1.043789	0.0	0.0	0.069688	0.43533	
*139								
RCC	0.0	0.0	1.043789	0.0	0.0	0.069688	.8	
*140								
RCC	0.0	0.0	1.043789	0.0	0.0	0.069688	1.027288	
*141								
RCC	0.9087555	0.0	1.043789	0.0	0.0	0.069688	0.0248889	
*142								
RCC	0.0	0.9087555	1.043789	0.0	0.0	0.069688	0.0248889	
*143								
RCC	-0.9087555	0.0	1.043789	0.0	0.0	0.069688	0.0248889	
*144								
RCC	0.0	-0.9087555	1.043789	0.0	0.0	0.069688	0.0248889	
*145								
RCC	0.0	0.0	1.113477	0.0	0.0	0.05	0.518942	
*146								
RCC	0.0	0.0	1.113477	0.0	0.0	0.05	0.73422	
*147								
RCC	0.0	0.0	1.163477	0.0	0.0	0.04	0.373111	
*148								
RCC	0.0	0.0	1.163477	0.0	0.0	0.04	0.43533	
*149								
RCC	0.0	0.0	1.163477	0.0	0.0	0.04	0.73422	
*150								
RCC	0.0	0.0	1.203477	0.0	0.0	0.04	0.373111	
*151								
RCC	0.0	0.0	1.203477	0.0	0.0	0.04	0.43533	
*152								

RCC	0.0	0.0	1.203477	0.0	0.0	0.04	0.73422	
*153								
RCC	0.0	0.0	1.243477	0.0	0.0	0.05	0.373111	
*154								
RCC	0.0	0.0	1.243477	0.0	0.0	0.05	0.73422	
*155								
TRC	0.0	0.0	1.293477	0.0	0.0	0.059297	0.373111	0.43533
*156								
RCC	0.0	0.0	1.293477	0.0	0.0	0.059297	0.73422	
*157								
RCC	0.0	0.0	1.113477	0.0	0.0	0.239297	0.8	
*158								
RCC	0.0	0.0	1.113477	0.0	0.0	0.239297	1.027288	
*159								
RCC	0.9087555	0.0	1.113477	0.0	0.0	0.239297	0.0248889	
*160								
RCC	0.0	0.9087555	1.113477	0.0	0.0	0.239297	0.0248889	
*161								
RCC	-0.9087555	0.0	1.113477	0.0	0.0	0.239297	0.0248889	
*162								
RCC	0.0	-0.9087555	1.113477	0.0	0.0	0.239297	0.0248889	
*163								
RCC	0.0	0.0	1.352774	0.0	0.0	0.007620	0.4064	
*164								
RCC	0.0	0.0	1.352774	0.0	0.0	0.007620	0.6096	
*165								
RCC	0.0	0.0	1.352774	0.0	0.0	0.007620	1.001777	
*166								
RCC	0.0	0.0	1.352774	0.0	0.0	0.007620	1.027288	
*167								
RCC	0.9087555	0.0	1.352774	0.0	0.0	0.007620	0.0248889	
*168								
RCC	0.0	0.9087555	1.352774	0.0	0.0	0.007620	0.0248889	
*169								
RCC	-0.9087555	0.0	1.352774	0.0	0.0	0.007620	0.0248889	
*170								
RCC	0.0	-0.9087555	1.352774	0.0	0.0	0.007620	0.0248889	
*171								
RCC	0.0	0.0	1.360394	0.0	0.0	0.050796	0.4064	
*172								
RCC	0.0	0.0	1.360394	0.0	0.0	0.050796	1.001777	
*173								
RCC	0.0	0.0	1.360394	0.0	0.0	0.050796	1.027288	
*174								
RCC	0.9087555	0.0	1.360394	0.0	0.0	0.050796	0.0248889	
*175								
RCC	0.0	0.9087555	1.360394	0.0	0.0	0.050796	0.0248889	
*176								
RCC	-0.9087555	0.0	1.360394	0.0	0.0	0.050796	0.0248889	
*177								
RCC	0.0	-0.9087555	1.360394	0.0	0.0	0.050796	0.0248889	
*178								
RCC	0.0	0.0	1.41119	0.0	0.0	0.007620	0.4064	
*179								
RCC	0.0	0.0	1.41119	0.0	0.0	0.007620	0.6096	
*180								
RCC	0.0	0.0	1.41119	0.0	0.0	0.007620	1.001777	
*181								
RCC	0.0	0.0	1.41119	0.0	0.0	0.007620	1.027288	
*182								
RCC	0.9087555	0.0	1.41119	0.0	0.0	0.007620	0.0248889	
*183								
RCC	0.0	0.9087555	1.41119	0.0	0.0	0.007620	0.0248889	
*184								
RCC	-0.9087555	0.0	1.41119	0.0	0.0	0.007620	0.0248889	
*185								
RCC	0.0	-0.9087555	1.41119	0.0	0.0	0.007620	0.0248889	
*186								
RCC	0.0	0.0	1.41881	0.0	0.0	0.099555	0.5080	
*187								
RCC	0.0	0.0	1.41881	0.0	0.0	0.099555	1.001777	
*188								
RCC	0.0	0.0	1.41881	0.0	0.0	0.099555	1.027288	
*189								
RCC	0.9087555	0.0	1.418810	0.0	0.0	0.099555	0.0248889	
*190								
RCC	0.0	0.9087555	1.418810	0.0	0.0	0.099555	0.0248889	
*191								
RCC	-0.9087555	0.0	1.418810	0.0	0.0	0.099555	0.0248889	
*192								

RCC	0.0	-0.9087555	1.418810	0.0	0.0	0.099555	0.0248889
*193							
RCC	0.0	0.0	1.518365	0.0	0.0	0.435556	0.5080
*194							
RCC	0.0	0.0	1.518365	0.0	0.0	0.435556	1.001777
*195							
RCC	0.0	0.0	1.518365	0.0	0.0	0.435556	1.027288
*196							
RCC	0.9087555	0.0	1.518365	0.0	0.0	0.435556	0.734222
*197							
RCC	0.0	0.9087555	1.518365	0.0	0.0	0.435556	0.734222
*198							
RCC	-0.9087555	0.0	1.518365	0.0	0.0	0.435556	0.734222
*199							
RCC	0.0	-0.9087555	1.518365	0.0	0.0	0.435556	0.734222
*200							
RCC	0.0	0.0	1.953921	0.0	0.0	0.018044	0.5080
*201							
RCC	0.0	0.0	1.953921	0.0	0.0	0.018044	1.001777
*202							
RCC	0.0	0.0	1.953921	0.0	0.0	0.018044	1.027288
*203							
RCC	0.0	0.0	1.971965	0.0	0.0	0.074666	1.027288
*204							
RCC	0.0	0.0	2.046631	0.0	0.0	0.248889	1.5240
*205							
RCC	0.0	0.0	0.0	0.0	0.0	2.046631	1.5240
*206	AL TOP PLATE						
RPP	-2.54	7.62	-2.54	7.62	-0.2032	0.0	
*207	AL BOTTOM PLATE						
RPP	-2.54	7.62	-2.54	7.62	7.5565	8.1661	
*208	LOW X SIDE PLATE						
RPP	-2.54	-2.3368	-2.54	7.62	0.0	7.5565	
*209	HIGH X SIDE PLATE						
RPP	7.4168	7.62	-2.54	7.62	0.0	7.5565	
*210	LOW Y SIDE PLATE						
RPP	-2.3368	7.4168	-2.54	-2.3368	0.0	7.5565	
*211	HIGH Y SIDE PLATE						
RPP	-2.3368	7.4168	7.4168	7.62	0.0	7.5565	
*212	HOLE IN CASE TOP FOR APERTURE						
RCC	0.0	0.0	-0.2032	0.0	0.0	0.2032	0.5334
*213-218	MICARTA BOARDS (6)						
RPP	-2.3368	7.4168	-2.3368	7.4168	2.295525	2.454275	
RPP	-2.3368	7.4168	-2.3368	7.4168	3.137535	3.296285	
RPP	-2.3368	7.4168	-2.3368	7.4168	3.979545	4.138295	
RPP	-2.3368	7.4168	-2.3368	7.4168	4.821555	4.980305	
RPP	-2.3368	7.4168	-2.3368	7.4168	5.663565	5.822315	
RPP	-2.3368	7.4168	-2.3368	7.4168	6.505575	6.64325	
*219-224	VOIDS BETWEEN MICARTA BOARDS						
RPP	-2.3368	7.4168	-2.3368	7.4168	2.454275	3.137535	
RPP	-2.3368	7.4168	-2.3368	7.4168	3.296285	3.979545	
RPP	-2.3368	7.4168	-2.3368	7.4168	4.138295	4.821555	
RPP	-2.3368	7.4168	-2.3368	7.4168	4.980305	5.663565	
RPP	-2.3368	7.4168	-2.3368	7.4168	5.822315	6.505575	
RPP	-2.3368	7.4168	-2.3368	7.4168	6.64325	7.5565	
*225-228	STAINLESS CORNER BOLTS (4)						
RCC	-1.79605	-1.79605	-0.2032	0.0	0.0	8.3693	0.1058333
RCC	5.82395	-1.79605	-0.2032	0.0	0.0	8.3693	0.1058333
RCC	5.82395	5.82395	-0.2032	0.0	0.0	8.3693	0.1058333
RCC	-1.79605	5.82395	-0.2032	0.0	0.0	8.3693	0.1058333
*229-234	PMMA SPACERS WRAPPED AROUND CORNER BOLT#1						
RCC	-1.79605	-1.79605	2.454275	0.0	0.0	0.68326	0.21167
RCC	-1.79605	-1.79605	3.296285	0.0	0.0	0.68326	0.21167
RCC	-1.79605	-1.79605	4.138295	0.0	0.0	0.68326	0.21167
RCC	-1.79605	-1.79605	4.980305	0.0	0.0	0.68326	0.21167
RCC	-1.79605	-1.79605	5.822315	0.0	0.0	0.68326	0.21167
RCC	-1.79605	-1.79605	6.664325	0.0	0.0	0.892175	0.21167
*235-240	PMMA SPACERS WRAPPED AROUND CORNER BOLT#2						
RCC	5.82395	-1.79605	2.454275	0.0	0.0	0.68326	0.21167
RCC	5.82395	-1.79605	3.296285	0.0	0.0	0.68326	0.21167
RCC	5.82395	-1.79605	4.138295	0.0	0.0	0.68326	0.21167
RCC	5.82395	-1.79605	4.980305	0.0	0.0	0.68326	0.21167
RCC	5.82395	-1.79605	5.822315	0.0	0.0	0.68326	0.21167

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RCC 5.82395 -1.79605 6.664325 0.0 0.0 0.892175 0.21167
*241-246 PMMA SPACERS WRAPPED AROUND CORNER BOLT#3
RCC 5.82395 5.82395 2.454275 0.0 0.0 0.68326 0.21167
RCC 5.82395 5.82395 3.296285 0.0 0.0 0.68326 0.21167
RCC 5.82395 5.82395 4.138295 0.0 0.0 0.68326 0.21167
RCC 5.82395 5.82395 4.980305 0.0 0.0 0.68326 0.21167
RCC 5.82395 5.82395 5.822315 0.0 0.0 0.68326 0.21167
RCC 5.82395 5.82395 6.664325 0.0 0.0 0.892175 0.21167
*247-252 PMMA SPACERS WRAPPED AROUND CORNER BOLT#4
RCC -1.79605 5.82395 2.454275 0.0 0.0 0.68326 0.21167
RCC -1.79605 5.82395 3.296285 0.0 0.0 0.68326 0.21167
RCC -1.79605 5.82395 4.138295 0.0 0.0 0.68326 0.21167
RCC -1.79605 5.82395 4.980305 0.0 0.0 0.68326 0.21167
RCC -1.79605 5.82395 5.822315 0.0 0.0 0.68326 0.21167
RCC -1.79605 5.82395 6.664325 0.0 0.0 0.892175 0.21167
*253 VOID REGION BETWEEN TOP PLATE AND FIRST MICARTA BOARD
RPP -2.3368 7.4168 -2.3368 7.4168 0.0 2.295525
*254 EXTERIOR VOID ABOVE TOP Z PLATE
RPP -3.54 8.62 -3.54 8.62 -2.2032 -0.2032
*255 EXTERIOR VOID BELOW BOTTOM Z PLATE
RPP -3.54 8.62 -3.54 8.62 8.1661 10.1661
*256 EXTERIOR VOID OUTSIDE LOWER X PLATE
RPP -3.54 -2.54 -3.54 8.62 0.0 7.5565
*257 EXTERIOR VOID OUTSIDE UPPER X PLATE
RPP 7.62 8.62 -3.54 8.62 0.0 7.5565
*258 EXTERIOR VOID OUTSIDE LOWER Y PLATE
RPP -2.54 7.62 -3.54 -2.54 0.0 7.5565
*259 EXTERIOR VOID OUTSIDE UPPER Y PLATE
RPP -2.54 7.62 7.62 8.62 0.0 7.5565
*260
SPH 0.0 0.0 1.2 30.0
END
*VOID
Z01 +1
Z02 +2
Z03 +3
Z04 +4
Z05 +5
Z06 +6
Z07 +7
Z08 +8
Z09 +9
Z10 +10
Z11 +11
Z12 +12
Z13 +13
Z14 +14
Z15 +15
Z16 +16
Z17 +17
Z18 +18
*COPPER
Z19 +19 -1
Z20 +20 -2
Z21 +21 -3
Z22 +22 -4
Z23 +23 -5
Z24 +24 -6
Z25 +25 -7
Z26 +26 -8
Z27 +27 -9
Z28 +28 -10
Z29 +29 -11
Z30 +30 -12
Z31 +31 -13
Z32 +32 -14
Z33 +33 -15
Z34 +34 -16
Z35 +35 -17
Z36 +36 -18
Z37 +37 -39
Z38 +38 -40
*AL FOIL
Z39 +39
*TUNGSTEN DISK
Z40 +40 -41
*VOID APERTURE
Z41 +41
*COPPER
Z42 +42 -19 -20 -21 -22 -23 -24 -25 -26 -27 -28 -29 -30 -31 -32

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*VOID
 Z43 +43 -33 -34 -35 -36 -37 -38 -44 -45 -46 -47
 *PMMA RODS
 Z44 +44
 Z45 +45
 Z46 +46
 Z47 +47
 *STAINLESS BOLTS
 Z48 +48
 Z49 +49
 Z50 +50
 Z51 +51
 Z52 +52
 Z53 +53
 Z54 +54
 Z55 +55
 *VOID
 Z56 +56
 *GOLD
 Z57 +57 -56
 *VOID
 Z58 +58 -56 -57 -59 -60 -61 -62
 *PMMA RODS
 Z59 +59
 Z60 +60
 Z61 +61
 Z62 +62
 *VOID
 Z63 +63
 *PCB ANNULUS
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 *DFT ELECTRICALLY ACTIVE PART
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 *DFT ELECTRICALLY INACTIVE PART
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 *PMMA
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 *VOID
 Z95 +95 -92 -93 -94 -96 -97 -98 -99

*PMMA RODS
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 *VOID
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 *BRASS
 Z109 +115 -114
 *PMMA
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 *PMMA RODS
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 Z122 +122
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 *VOID ANNULUS
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 *PMMA RODS
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 Z128 +128
 Z129 +129
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 Z135 +135
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 *PMMA
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 *VOID
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 *PMMA RODS
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 Z142 +142
 Z143 +143
 Z144 +144

*DBT ELLECTRICALLY ACTIVE PART
 Z145 +145
 *DBT ELECTRICALLY INACTIVE PART
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 *VOID
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 *VOID
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 *BRASS ANNULUS
 Z154 +154 -153
 *VOID
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 Z190 +190
 Z191 +191
 Z192 +192

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*PMMA
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*PMMA
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*VOID
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Z205 +205
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-186 -187 -188 -189 -190 -191 -192 -193 -194 -195
-196 -197 -198 -199 -200 -201 -202 -203
*TOP PLATE WITH HOLE FOR INSTRUMENT AND 4 BOLT HOLES
Z206 +206 -212 -225 -226 -227 -228
*BOTTOM PLATE
Z207 +207
*X-PLATES
Z208 +208
Z209 +209
*Y-PLATES
Z210 +210
Z211 +211
*VOID REGION BETWEEN TOP PLATE AND FIRST MICARTA BOARD
*(EXCLUDES THE CEASE TELESCOPE, CORNER BOLTS)
Z212 +253 -1 -2 -3 -4 -5 -6 -7 -8 -9 -10 -11 -12 -13 -14 -15
-16 -17 -18 -19 -20 -21 -22 -23 -24 -25 -26 -27 -28
-29 -30 -31 -32 -33 -34 -35 -36 -37 -38 -39 -40 -41
-42 -43 -44 -45 -46 -47 -48 -49 -50 -51 -52 -53 -54
-55 -56 -57 -58 -59 -60 -61 -62 -63 -64 -65 -66 -67
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-186 -187 -188 -189 -190 -191 -192 -193 -194 -195
-196 -197 -198 -199 -200 -201 -202 -203 -204 -205
-225 -226 -227 -228
*MICARTA BOARDS (6) EXCLUDES BOLTS
Z213 +213 -225 -226 -227 -228
Z214 +214 -225 -226 -227 -228
Z215 +215 -225 -226 -227 -228
Z216 +216 -225 -226 -227 -228
Z217 +217 -225 -226 -227 -228
Z218 +218 -225 -226 -227 -228
*VOIDS BETWEEN MICARTA BOARDS (6) (EXCLUDES BOLTS AND PMMA SPACERS)
Z219 +219 -229 -225 -235 -226 -241 -227 -247 -228
Z220 +220 -230 -225 -236 -226 -242 -227 -248 -228

```

Z221 +221 -231 -225 -237 -226 -243 -227 -249 -228
 Z222 +222 -232 -225 -238 -226 -244 -227 -250 -228
 Z223 +223 -233 -225 -239 -226 -245 -227 -251 -228
 Z224 +224 -234 -225 -240 -226 -246 -227 -252 -228
 *VOID REGION ABOVE TOP Z-PLATE
 Z225 +254
 *VOID REGION BELOW BOTTOM Z-PLATE
 Z226 +255
 *VOID REGION OUTSIDE LOWER X-PLATE
 Z227 +256
 *VOID REGION OUTSIDE UPPER X-PLATE
 Z228 +257
 *VOID REGION OUTSIDE LOWER Y-PLATE
 Z229 +258
 *VOID REGION OUTSIDE UPPER Y-PLATE
 Z230 +259
 *VOID CYLINDRICAL REGION ABOVE INSTRUMENT APERTURE
 Z231 +212
 *CORNER BOLT 1
 Z232 +225
 *CORNER BOLT 2
 Z233 +226
 *CORNER BOLT 3
 Z234 +227
 *CORNER BOLT 4
 Z235 +228
 *PMMA SPACERS AROUND CORNER BOLT 1
 Z236 +229 -225
 Z237 +230 -225
 Z238 +231 -225
 Z239 +232 -225
 Z240 +233 -225
 Z241 +234 -225
 *PMMA SPACERS AROUND CORNER BOLT 2
 Z242 +235 -226
 Z243 +236 -226
 Z244 +237 -226
 Z245 +238 -226
 Z246 +239 -226
 Z247 +240 -226
 *PMMA SPACERS AROUND CORNER BOLT 3
 Z248 +241 -227
 Z249 +242 -227
 Z250 +243 -227
 Z251 +244 -227
 Z252 +245 -227
 Z253 +246 -227
 *PMMA SPACERS AROUND CORNER BOLT 4
 Z254 +247 -228
 Z255 +248 -228
 Z256 +249 -228
 Z257 +250 -228
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 Z259 +252 -228
 *ESCAPE
 Z260 +260
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 -246 -247 -248 -249 -250 -251 -252 -253 -254 -255
 -256 -257 -258 -259

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0.001853333	0.001287037	0.000823704	0.022267310	0.024378050
0.026385830	0.028290650	0.030092500	0.031791390	0.033387310
0.034880270	0.036270270	0.037557310	0.038741380	0.039822490
0.040800640	0.041675830	0.042448050	0.043117310	0.043683610
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0.017615106	0.098299384	0.016013781	0.089363337	0.063128665
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0.000048002	0.030477827	0.011012329	0.098625898	0.090384185
0.000135619	0.000135619	0.000135619	0.000135619	0.042301673
0.042376671	0.017493874	0.006320933	0.043927863	0.017493874
0.006320933	0.043927863	0.021867344	0.062811002	0.025933357
0.074490078	0.075869732	0.310364306	0.000465692	0.000465692
0.000465692	0.000465692	0.003953778	0.004942222	0.015128090
0.001239162	0.000014829	0.000014829	0.000014829	0.000014829
0.026356442	0.133396149	0.008260399	0.000098853	0.000098853
0.000098853	0.000098853	0.003953778	0.004942222	0.015128090
0.001239162	0.000014829	0.000014829	0.000014829	0.000014829
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15.07997	15.07997	13.07801	64.61568	64.61568
64.61568	64.61568	64.61568	86.37763	147.8656
147.8656	91.88704	91.88704	76.77404	76.77404
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6	0	1	10	8
6	7	0	10	8
6	0	1	2	8
6	0	0	2	8
0	7	1	2	8

Actual input data must be arranged in a single column. Four columns are used here to conserve space.

***** SOURCE *****
 ELECTRONS
 ENERGY 9.9
 POSITION 0.0 0.0 -0.25
 RADIUS 1.4
 * DEFAULT DIRECTION
 DIRECTION 0.0 0.0
 ***** OPTIONS *****
 HISTORIES 25000

APPENDIX 6

ITS-XGEN Input File to Generate Electron and Photon Cross Section Tables for CEASE Telescope

(For chemical compounds, material density [g/cm³] must be specified, and material compositions are defined by specifying elemental weight fractions.)

```
TITLE
  CEASE 10 MEV TEST PROBLEM (10 MATL'S)
ENERGY 12.0
*BRASS
MATERIAL CU 0.7      NI 0.3
  DENSITY 8.53
*ALUMINUM
MATERIAL AL
*TUNGSTEN ALLOY
MATERIAL W 0.95  NI 0.035  CU 0.015
  DENSITY 18.0
*GOLD
MATERIAL AU
*MICARTA FR-4
MATERIAL O 0.4691566  SI 0.2573466  CA .1478866  AL 0.06351008
      B 0.01552755  MA 0.01483714  FE 0.01279773
      TI 0.003597  MG 0.030152
  DENSITY 2.54
*STAINLESS
MATERIAL FE 0.71  MN 0.065  SI 0.01  CU 0.17  NI 0.045
  DENSITY 8.0
* CONDUCTIVE SILICONE ELASTOMER
MATERIAL SI 0.0947  O 0.0539  C 0.0810  H 0.0204  NI 0.3770  AG 0.3730
  DENSITY 7.4723
*PMMA
MATERIAL H 0.080538  C 0.599848  O 0.319614
  DENSITY 1.190
*SILICON
MATERIAL SI
*COPPER ALLOY 145
MATERIAL CU 0.995  TE 0.005
  DENSITY 8.92
```


APPENDIX 7

ACCEPT Output Listing of Energy and Charge Deposition in CEASE Telescope, Frame and Case resulting from 9.9 MeV Electron Beam Normally Incident on Case Top Directly above Telescope ("SZONE" numbers correspond to the cell labels shown in Figure 13)

SZONE MAT.	ENERGY AND CHARGE DEPOSITION (NORMALIZED TO ONE SOURCE PARTICLE)				CHARGE (ELECTRONS)			
	ENERGY (MEV)		TOTAL		PRIM		KNCK	
	PRIM	KNCK	G-SEC	TOTAL	PRIM	KNCK	G-SEC	TOTAL
1 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
10 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
11 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
12 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
13 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
14 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
15 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
16 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
17 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
18 0	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
19 10	5.312E-02	1.761E-04	7.516E-04	5.405E-02	1.360E-03	17 5.200E-04	99 -1.200E-04	99 1.760E-03
20 10	6.493E-02	7.804E-05	1.032E-03	6.604E-02	2.000E-03	13 5.200E-04	99 8.000E-05	99 2.600E-03
21 10	7.762E-02	1.617E-03	1.235E-03	8 7.724E-02	3.680E-03	9 -1.280E-03	42 0.000E+00	99 2.400E-03
22 10	8.712E-02	2.225E-04	1.578E-03	11 8.892E-02	4.800E-03	10 -4.000E-05	99 8.000E-05	99 4.840E-03
23 10	9.619E-02	2.784E-04	2.033E-03	12 9.851E-02	5.320E-03	3 2.000E-04	99 -1.200E-04	99 5.400E-03
24 10	1.071E-01	2.224E-04	2.047E-03	7 1.089E-01	8.280E-03	8 1.600E-04	99 -2.800E-04	98 8.160E-03
25 10	1.126E-01	2.016E-03	2.321E-03	6 1.129E-01	9.560E-03	7 -1.440E-03	43 -4.000E-05	99 8.080E-03
26 10	1.162E-01	4.533E-04	2.241E-03	9 1.189E-01	1.032E-02	6 2.000E-04	99 -8.000E-05	99 1.044E-02
27 10	1.168E-01	2.122E-04	2.617E-03	10 1.192E-01	1.236E-02	3 -6.000E-04	99 -3.600E-04	54 1.140E-02
28 10	1.173E-01	3.089E-04	3.152E-03	8 1.213E-01	1.144E-02	7 1.000E-03	78 3.600E-04	90 1.280E-02
29 10	1.172E-01	1.3.888E-04	2.994E-03	8 1.198E-01	1.340E-02	3 -2.400E-04	99 -2.000E-04	99 1.296E-02
30 10	1.143E-01	7.389E-04	3.410E-03	8 1.185E-01	1.464E-02	5 9.600E-04	72 -2.400E-04	99 1.536E-02
31 10	1.071E-01	2.4.644E-04	3.739E-03	8 1.104E-01	1.352E-02	4 -8.000E-04	45 3.600E-04	99 1.308E-02
32 10	1.006E-01	2.4.166E-04	3.501E-03	6 1.045E-01	1.424E-02	3 4.000E-04	99 -5.200E-04	57 1.412E-02
33 10	9.533E-02	3.4.171E-04	3.377E-03	6 9.912E-02	1.336E-02	6 8.000E-04	78 -3.659E-20	99 1.416E-02
34 10	9.120E-02	3.3.282E-04	3.307E-03	7 9.418E-02	1.348E-02	5 -2.800E-04	99 -4.000E-05	99 1.372E-02
35 10	8.563E-02	3.8.710E-04	3.207E-03	8 8.796E-02	1.412E-02	8 2.800E-04	99 -2.400E-04	99 1.360E-02
36 10	8.042E-02	3.9.181E-04	3.995E-03	7 8.533E-02	1.332E-02	6 -1.200E-04	99 2.400E-04	99 1.344E-02
37 10	1.243E-03	7.5.473E-05	1.202E-04	19 1.309E-03	4.000E-05	99 -4.000E-05	99 -1.600E-04	67 -1.600E-04

[illegible]

SZONE	MAT.	ENERGY (MEV)										CHARGE (ELECTRONS)										TOTAL											
		ENERGY AND CHARGE DEPOSITION (NORMALIZED TO ONE SOURCE PARTICLE)										CHARGE (ELECTRONS)																					
		PRIM	KNOCK	G-SEC	TOTAL	PRIM	KNOCK	G-SEC	TOTAL	PRIM	KNOCK	G-SEC	TOTAL																				
101	7	1.807E-03	14	4.790E-05	99	2.619E-04	23	2.117E-03	13	2.800E-04	30	4.000E-05	99	-1.600E-04	76	1.600E-04	67	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
102	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
103	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
104	7	3.234E-03	9	1.858E-04	65	3.519E-04	23	3.772E-03	10	4.800E-04	21	1.200E-04	87	1.200E-04	87	7.200E-04	32	7.200E-04	32	7.200E-04	32	7.200E-04	32	7.200E-04	32	7.200E-04	32	7.200E-04	32	7.200E-04	32	7.200E-04	32
105	1	2.019E-02	4	2.662E-04	63	2.962E-03	8	2.342E-02	3	5.240E-03	10	3.200E-04	76	4.800E-04	46	6.040E-03	10	6.040E-03	10	6.040E-03	10	6.040E-03	10	6.040E-03	10	6.040E-03	10	6.040E-03	10	6.040E-03	10	6.040E-03	10
106	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
107	1	2.750E-02	4	1.315E-04	99	4.352E-03	10	3.198E-02	4	7.680E-03	8	2.000E-04	80	-1.600E-04	99	7.720E-03	8	7.720E-03	8	7.720E-03	8	7.720E-03	8	7.720E-03	8	7.720E-03	8	7.720E-03	8	7.720E-03	8	7.720E-03	8
108	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
109	1	1.479E-02	9	7.755E-05	99	3.565E-03	9	1.828E-02	6	4.080E-03	13	4.000E-05	99	-1.600E-04	99	3.960E-03	12	3.960E-03	12	3.960E-03	12	3.960E-03	12	3.960E-03	12	3.960E-03	12	3.960E-03	12	3.960E-03	12	3.960E-03	12
110	8	4.576E-03	4	-1.144E-04	99	4.623E-04	12	4.923E-03	5	1.160E-03	17	-2.800E-04	60	-1.200E-04	99	7.600E-04	35	7.600E-04	35	7.600E-04	35	7.600E-04	35	7.600E-04	35	7.600E-04	35	7.600E-04	35	7.600E-04	35	7.600E-04	35
111	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
112	8	3.773E-05	29	4.729E-06	99	3.348E-06	99	4.581E-05	19	4.000E-05	99	0.000E+00	99	0.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99
113	8	6.428E-05	29	0.000E+00	99	7.323E-06	99	7.160E-05	29	4.000E-05	99	0.000E+00	99	0.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99	4.000E+00	99
114	8	5.250E-05	39	0.000E+00	99	4.626E-06	99	6.274E-05	42	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
115	8	5.994E-05	27	0.000E+00	99	2.797E-06	99	6.274E-05	28	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
116	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
117	5	1.331E-02	5	4.703E-05	99	1.359E-03	13	1.471E-02	6	3.280E-03	9	4.000E-05	99	1.600E-04	99	3.480E-03	16	3.480E-03	16	3.480E-03	16	3.480E-03	16	3.480E-03	16	3.480E-03	16	3.480E-03	16	3.480E-03	16	3.480E-03	16
118	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
119	8	1.872E-05	57	0.000E+00	99	0.000E+00	99	1.872E-05	57	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
120	8	2.318E-05	45	0.000E+00	99	0.000E+00	99	2.318E-05	45	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
121	8	5.291E-05	86	0.000E+00	99	0.000E+00	99	5.291E-05	86	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
122	8	2.947E-06	99	0.000E+00	99	2.509E-06	99	5.456E-06	67	4.000E-05	99	0.000E+00	99	0.000E+00	99	4.000E-05	99	4.000E-05	99	4.000E-05	99	4.000E-05	99	4.000E-05	99	4.000E-05	99	4.000E-05	99	4.000E-05	99	4.000E-05	99
123	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
124	1	1.175E-02	8	1.849E-04	53	2.946E-03	10	1.488E-02	8	3.920E-03	8	2.000E-04	86	-2.800E-04	99	3.840E-03	9	3.840E-03	9	3.840E-03	9	3.840E-03	9	3.840E-03	9	3.840E-03	9	3.840E-03	9	3.840E-03	9	3.840E-03	9
125	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
126	8	2.001E-06	99	0.000E+00	99	0.000E+00	99	2.001E-06	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
127	8	7.397E-06	52	0.000E+00	99	0.000E+00	99	7.397E-06	52	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99

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[illegible]

SZONE	MAT.	PRIM	KNCK	ENERGY (MEV)	ENERGY AND CHARGE DEPOSITION (NORMALIZED TO ONE SOURCE PARTICLE)	PRIM	KNCK	CHARGE (ELECTRONS)	G-SEC	TOTAL
173	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
174	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
175	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
176	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
177	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
178	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
179	4	8.155E-04	22	4.168E-06	99	6.538E-04	9	1.473E-03	10	1.626E-20
180	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
181	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
182	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
183	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
184	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
185	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
186	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
187	8	4.790E-03	4	4.759E-07	99	6.853E-04	11	5.474E-03	4	1.520E-03
188	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
189	8	0.000E+00	99	0.000E+00	99	1.639E-06	99	1.639E-06	99	0.000E+00
190	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
191	8	0.000E+00	99	0.000E+00	99	2.091E-06	99	2.091E-06	99	0.000E+00
192	8	0.000E+00	99	0.000E+00	99	1.601E-06	99	1.601E-06	99	0.000E+00
193	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
194	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
195	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00
196	8	5.449E-03	13	6.392E-05	99	1.540E-03	11	7.054E-03	11	2.040E-03
197	8	4.738E-03	11	1.371E-04	38	1.797E-03	11	6.673E-03	10	2.160E-03
198	8	6.684E-03	10	9.946E-05	51	1.252E-03	18	8.035E-03	10	2.480E-03
199	8	6.474E-03	11	7.712E-05	99	1.659E-03	9	8.211E-03	9	2.440E-03
200	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00

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SZONE	MAT.	ENERGY (MEV)										CHARGE (ELECTRONS)					
		PRIM		KNOCK		G-SEC		TOTAL		PRIM		KNOCK		G-SEC		TOTAL	
		ENERGY AND CHARGE DEPOSITION (NORMALIZED TO ONE SOURCE PARTICLE)															
218	5	5.432E-04	44	1.811E-05	99	3.730E-03	6	4.292E-03	9	2.800E-04	37	4.000E-05	99	-7.200E-04	63	-4.000E-04	99
219	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
220	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
221	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
222	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
223	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
224	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
225	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
226	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
227	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
228	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
229	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
230	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
231	0	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
232	6	8.162E-04	20	1.939E-05	99	4.775E-04	28	1.313E-03	12	2.800E-04	30	4.000E-05	99	0.000E+00	99	3.200E-04	41
233	6	2.323E-04	54	0.000E+00	99	1.364E-04	50	3.687E-04	32	4.000E-05	99	0.000E+00	99	4.000E-05	99	8.000E-05	67
234	6	6.987E-05	99	1.869E-06	99	3.813E-05	94	1.099E-04	68	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
235	6	1.618E-04	54	0.000E+00	99	6.748E-05	51	2.293E-04	38	8.000E-05	67	0.000E+00	99	0.000E+00	99	8.000E-05	67
236	8	1.260E-05	99	0.000E+00	99	1.201E-05	84	2.461E-05	61	0.000E+00	99	0.000E+00	99	4.000E-05	99	4.000E-05	99
237	8	1.083E-05	99	0.000E+00	99	1.448E-06	91	1.227E-05	88	0.000E+00	99	0.000E+00	99	4.000E-05	99	4.000E-05	99
238	8	0.000E+00	99	0.000E+00	99	4.187E-05	69	4.187E-05	69	0.000E+00	99	0.000E+00	99	4.000E-05	99	4.000E-05	99
239	8	0.000E+00	99	0.000E+00	99	1.042E-04	71	1.042E-04	71	0.000E+00	99	0.000E+00	99	8.000E-05	67	8.000E-05	67
240	8	0.000E+00	99	0.000E+00	99	1.454E-05	78	1.454E-05	78	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
241	8	2.694E-05	99	7.734E-06	99	6.477E-05	52	6.477E-05	52	0.000E+00	99	0.000E+00	99	4.000E-05	99	4.000E-05	99
242	8	2.100E-06	99	0.000E+00	99	1.107E-05	89	1.317E-05	77	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
243	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
244	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
245	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
246	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
247	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
248	8	0.000E+00	99	0.000E+00	99	5.119E-06	99	5.119E-06	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
249	8	0.000E+00	99	0.000E+00	99	5.444E-07	99	5.444E-07	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
250	8	9.843E-06	67	0.000E+00	99	0.000E+00	99	9.843E-06	67	4.000E-05	99	0.000E+00	99	0.000E+00	99	4.000E-05	99
ENERGY AND CHARGE DEPOSITION (NORMALIZED TO ONE SOURCE PARTICLE)																	
251	8	8.357E-06	99	0.000E+00	99	0.000E+00	99	8.357E-06	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
252	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
253	8	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
254	8	3.183E-05	73	0.000E+00	99	1.299E-07	99	3.196E-05	73	4.000E-05	99	0.000E+00	99	0.000E+00	99	4.000E-05	99
255	8	0.000E+00	99	0.000E+00	99	4.182E-06	99	4.182E-06	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
256	8	0.000E+00	99	1.763E-05	99	0.000E+00	99	1.763E-05	99	0.000E+00	99	4.000E-05	99	0.000E+00	99	4.000E-05	99
257	8	4.644E-05	99	0.000E+00	99	0.000E+00	99	4.644E-05	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
258	8	4.721E-05	99	0.000E+00	99	0.000E+00	99	4.721E-05	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
259	8	0.000E+00	99	0.000E+00	99	3.458E-06	99	3.458E-06	99	0.000E+00	99	0.000E+00	99	0.000E+00	99	0.000E+00	99
0	TOTAL	8.292E+00	0	-1.792E-02	4	4.512E-01	1	8.725E+00	0	9.400E-01	0	-5.640E-03	10	-6.200E-03	6	9.281E-01	0
THE ENERGY CONSERVATION FRACTION IS .9991906360461E+00																	

APPENDIX 8 **CYLTRAN Input File for 6.0 MeV Electron Beam Disk Source** **Normally Incident on the CEASE Telescope Top Surface**

TITLE
 6.0 MEV CEASE CYLTRAN TEST FRONT ENTRY, NORMAL INCIDENCE
 ***** GEOMETRY *****

GEOMETRY 126

0.0	0.02540	0.0	0.53340	0
0.02540	0.05080	0.0	0.50800	0
0.05080	0.07620	0.0	0.48260	0
0.07620	0.10160	0.0	0.45720	0
0.10160	0.12700	0.0	0.43180	0
0.12700	0.15240	0.0	0.40640	0
0.15240	0.17780	0.0	0.38100	0
0.17780	0.20320	0.0	0.35560	0
0.20320	0.22860	0.0	0.33020	0
0.22860	0.25400	0.0	0.30480	0
0.25400	0.27940	0.0	0.27940	0
0.27940	0.30480	0.0	0.25400	0
0.30480	0.33020	0.0	0.22860	0
0.33020	0.35560	0.0	0.20320	0
0.35560	0.38100	0.0	0.17780	0
0.38100	0.40640	0.0	0.15240	0
0.40640	0.43180	0.0	0.12700	0
0.43180	0.45720	0.0	0.10160	0

*19

0.0	0.02540	0.53340	0.750711	10
0.02540	0.05080	0.50800	0.750711	10
0.05080	0.07620	0.48260	0.750711	10
0.07620	0.10160	0.45720	0.750711	10
0.10160	0.12700	0.43180	0.750711	10
0.12700	0.15240	0.40640	0.750711	10
0.15240	0.17780	0.38100	0.750711	10
0.17780	0.20320	0.35560	0.750711	10
0.20320	0.22860	0.33020	0.750711	10
0.22860	0.25400	0.30480	0.750711	10
0.25400	0.27940	0.27940	0.750711	10
0.27940	0.30480	0.25400	0.750711	10
0.30480	0.33020	0.22860	0.750711	10
0.33020	0.35560	0.20320	0.750711	10
0.35560	0.38100	0.17780	0.750711	10
0.38100	0.40640	0.15240	0.750711	10
0.40640	0.43180	0.12700	0.750711	10
0.43180	0.45720	0.10160	0.750711	10

*37

0.45720	0.45810	0.41910	0.750711	10
0.45810	0.50800	0.41910	0.750711	10
0.45720	0.45810	0.0	0.419100	2
0.45810	0.50800	0.02286	0.41910	3

*41

0.45810	0.50800	0.0	0.02286	0
0.0	0.35560	0.750711	1.06680	10
0.35560	0.50800	0.750711	1.06680	0

*44-47 PMMA RODS NEGLECTED
 *48-55 STAINLESS BOLTS NEGLECTED

*56

0.50800	0.51652	0.0	0.31110	0
0.50800	0.51652	0.31110	0.41910	4
0.50800	0.51652	0.41910	1.027288	0

*59-62 PMMA RODS NEGLECTED

*63

0.51652	0.56732	0.0	0.31110	0
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*64-67 PMMA RODS NEGLECTED

*68

0.51652	0.56732	0.31110	1.001777	5
0.51652	0.56732	1.001777	1.027288	0

*70 APPROXIMATE TRUNCATED CONE WITH CYLINDER

0.56732	0.592208	0.0	0.29866	0
0.56732	0.592208	0.29866	0.80000	1
0.56732	0.592208	0.80000	1.027288	0

*73-76 PMMA RODS NEGLECTED

0.51652	0.56732	1.001777	1.027288	0
*70 APPROXIMATE TRUNCATED CONE WITH CYLINDER				
0.56732	0.592208	0.0	0.29866	0
0.56732	0.592208	0.29866	0.80000	1
0.56732	0.592208	0.80000	1.027288	0
*73-76 PMMA RODS NEGLECTED				
*77				
0.592208	0.64199	0.0	0.28622	0
0.592208	0.64199	0.28622	0.80000	1
0.592208	0.64199	0.80000	1.027288	0
*80-83 PMMA RODS NEGLECTED				
*84				
0.64199	0.704212	0.0	0.28622	0
0.64199	0.704212	0.28622	0.34844	7
0.64199	0.704212	0.34844	0.80000	8
0.64199	0.704212	0.80000	1.027288	0
*88-91 PMMA RODS NEGLECTED				
*92				
0.704212	0.719212	0.0	0.40210	9
0.704212	0.719212	0.40210	0.73422	9
0.704212	0.719212	0.73422	0.80000	8
0.704212	0.719212	0.80000	1.027288	0
*96-99 PMMA RODS NEGLECTED				
*100				
0.719212	0.744212	0.0	0.28622	0
0.719212	0.744212	0.28622	0.34844	7
0.719212	0.744212	0.34844	0.73422	0
0.719212	0.918323	0.73422	0.80000	8
0.719212	0.918323	0.80000	1.027288	0
*105-108 PMMA RODS NEGLECTED				
*109				
0.744212	0.787657	0.0	0.28622	0
0.744212	0.787657	0.28622	0.34844	7
0.744212	0.787657	0.34844	0.73422	1
0.787657	0.856101	0.0	0.28622	0
0.787657	0.856101	0.28622	0.73422	1
*114 APPROXIMATE TRUNCATED CONE WITH CYLINDER				
0.856101	0.918323	0.0	0.31733	0
0.856101	0.918323	0.31733	0.73422	1
0.918323	0.969123	0.0	0.423111	0
0.918323	0.969123	0.423111	1.001777	5
0.918323	0.969123	1.001777	1.027288	0
*119-122 PMMA RODS NEGLECTED				
*123 APPROXIMATE TRUNCATED CONE WITH CYLINDER				
0.969123	1.019123	0.	0.398111	0
0.969123	1.019123	0.398111	0.80000	1
0.969123	1.019123	0.80000	1.027288	0
*126-129 PMMA RODS NEGLECTED				
*130				
1.019123	1.043789	0.	0.373111	0
1.019123	1.043789	0.373111	0.80000	1
1.019123	1.043789	0.80000	1.027288	0
*133-136 PMMA RODS NEGLECTED				
*137				
1.043789	1.113477	0.	0.373111	0
1.043789	1.113477	0.373111	0.43533	7
1.043789	1.113477	0.43533	0.80000	8
1.043789	1.113477	0.80000	1.027288	0
*141-144 PMMA RODS NEGLECTED				
*145				
1.113477	1.163477	0.0	0.518942	9
1.113477	1.163477	0.518942	0.73422	9
1.163477	1.203477	0.0	0.373111	0
1.163477	1.203477	0.373111	0.43533	7
1.163477	1.203477	0.43533	0.73422	0
1.203477	1.243477	0.	0.373111	0
1.203477	1.243477	0.373111	0.43533	7

1.203477	1.243477	0.43533	0.73422	1
1.243477	1.293477	0.	0.373111	0
1.243477	1.293477	0.373111	0.73422	1
*155 APPROXIMATE TRUNCATED CONE WITH CYLINDER				
1.293477	1.352774	0.	0.404221	0
1.293477	1.352774	0.404221	0.73422	1
1.113477	1.352774	0.73422	0.80000	8
1.113477	1.352774	0.80000	1.027288	0
*159-162 PMMA RODS NEGLECTED				
*163				
1.352774	1.360394	0.	0.4064	0
1.352774	1.360394	0.4064	0.6096	4
1.352774	1.360394	0.6096	1.001777	0
1.352774	1.360394	1.001777	1.027288	0
*167-170 PMMA RODS NEGLECTED				
*171				
1.360394	1.41119	0.	0.4064	0
1.360394	1.41119	0.4064	1.001777	5
1.360394	1.41119	1.001777	1.027288	0
*174-177 PMMA RODS NEGLECTED				
*178				
1.41119	1.418810	0.	0.4064	0
1.41119	1.418810	0.4064	0.6096	4
1.41119	1.418810	0.6096	1.001777	0
1.41119	1.418810	1.001777	1.027288	0
*182-185 PMMA RODS NEGLECTED				
*186				
1.41881	1.518365	0.	0.5080	0
1.41881	1.518365	0.5080	1.001777	8
1.41881	1.518365	1.001777	1.027288	0
*189-192 PMMA RODS NEGLECTED				
*193				
1.518365	1.953921	0.	0.5080	0
1.518365	1.953921	0.5080	1.001777	8
1.518365	1.953921	1.001777	1.027288	0
*196-199 PMMA RODS NEGLECTED				
*200				
1.953921	1.971965	0.	0.5080	0
1.953921	1.971965	0.5080	1.001777	8
1.953921	1.971965	1.001777	1.027288	0
1.971965	2.046631	0.	1.027288	0
2.046631	2.295520	0.	1.5420	10
0.0	0.50800	1.06680	1.5420	10
0.50800	2.046631	1.027288	1.5420	10
***** SOURCE *****				
ELECTRONS				
ENERGY 6.0				
POSITION 0.0 0.0 0.02				
RADIUS 1.4				
* DEFAULT DIRECTION				
DIRECTION 0.0 0.0				
***** OPTIONS *****				
HISTORIES 25000				